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Specification

(54) Title of Invention: LASER APPARATUS, METHOD FOR HEAT TREATING BY USING LASER BEAM AND METHOD FOR MANUFACTURING SEMICONDUCTOR DEVICE

(57) Summary

[PROBLEM TO BE SOLVED] To provide a method and an apparatus for heat treating of a semiconductor film by using a laser beam in correspondence with a large-scaled substrate, and a method and a laser apparatus for heat treating of a semiconductor film by using a laser beam.

[SOLUTION] A heat treating method of a semiconductor film by using a laser of the present invention is performed by which a linear laser beam with a first length formed by an optical system is converted by a slit 800 into a linear laser beam with a second length and is irradiated to a substrate 801. The slit is composed integrally of a base 804 and a movable plate 805, and the length in the longitudinal direction of the linear laser beam is regulated by the movable plate 805. The movable plate 805 can be fixed to the base 804, however, if a function to make it variable on the base 804 is added, the length in the longitudinal direction of the linear laser beam can be changed to a desired length within a variable range, consequently a large-scaled substrate can be heat treated.

[What is claimed]

[Claim 1] A laser apparatus comprising:

a laser oscillator;

at least one lens for forming a laser beam emitted from said laser oscillator into a linear laser beam with a first length,

a slit for forming a linear laser beam with a second length by changing the length in the longitudinal direction of said linear laser beam with the first length; and

a treating chamber in which said linear laser beam with the second length is irradiated to an object to be treated.

[Claim 2] A laser apparatus comprising:

a laser oscillator;

a step-shaped mirror for reflecting a laser beam emitted from said laser oscillator, and at least one lens for forming the laser beam reflected with said mirror into a linear laser beam with a first length,

a slit for forming a linear laser beam with a second length by changing the length in the longitudinal direction of said linear laser beam with the first length; and

a treating chamber in which said linear laser beam with the second length is irradiated to an object to be treated.

[Claim 3] A laser apparatus comprising:

a laser oscillator;

a micro lens array for condensing a laser beam emitted from said laser oscillator,

a light transmission medium which makes a laser beam passing through said micro lens array incident from a face of a first shape and emits it from a face of a second shape,

at least one lens for forming the laser beam passing through said light transmission medium into a linear laser beam with a first length,

a slit for forming a linear laser beam with a second length by changing the length in the longitudinal direction of said linear laser beam with the first length; and

a treating chamber in which said linear laser beam with the second length is irradiated to an object to be treated.

[Claim 4] A laser apparatus comprising:

a laser oscillator;

a wavelength converter for converting a laser beam emitted from said laser oscillator into a fundamental wave and a harmonic wave,

a first lens for forming said laser beam of the fundamental wave into a linear laser beam with

a first length,

a second lens for forming said laser beam of said harmonic wave into a linear laser beam with a second length,

a slit for forming a linear laser beam with a third length by changing the lengths in the longitudinal direction of said linear laser beam with the first length and said laser beam with the second length; and

a treating chamber in which said linear laser beam with the third length is irradiated to an object to be treated.

[Claim 5] A laser apparatus comprising:

a laser oscillator;

a wavelength converter for converting a laser beam emitted from said laser oscillator into a first harmonic wave and a second harmonic wave,

a first lens for forming said laser beam of the first harmonic wave into a linear laser beam with a first length,

a second lens for forming said laser beam of the second harmonic wave into a linear laser beam with a second length,

a slit for forming a linear laser beam with a third length by changing the lengths in the longitudinal direction of said linear laser beam with the first length and said laser beam with the second length; and

a treating chamber in which said linear laser beam with the third length is irradiated to an object to be treated.

[Claim 6] A laser apparatus wherein a light transmission medium is an optical fiber array in claim 3.

[Claim 7] A laser apparatus wherein said laser oscillator is one laser selected from Nd:YAG laser, Nd:YVO_4 laser, and Nd:$YA1O_3$ laser in any one from claim 1 to claim 6.

[Claim 8] A method for heat treating comprising:

a step for forming a laser beam emitted from a laser oscillator into a linear laser beam with a first length by at least one lens,

a step for forming a linear laser beam with a second length by changing the length in the longitudinal direction of said linear laser beam with the first length by a slit; and

a step for making said linear laser beam with the second length irradiate to an object to be treated.

[Claim 9] A method for heat treating comprising:

a step for reflecting a laser beam emitted from a laser oscillator with a step-shaped mirror,

a step for forming the laser beam reflected with said mirror into a linear laser beam with a first length by at least one lens,

a step for forming a linear laser beam with a second length by changing the length in the longitudinal direction of said linear laser beam with the first length by a slit; and

a step for making said linear laser beam with the second length irradiate to an object to be treated.

[Claim 10] A method for heat treating comprising:

a step for condensing a laser beam emitted from a laser oscillator with a micro lens array,

a step for making a laser beam passing through said micro lens array incident from a first-shaped face of light transmission medium and emitting it from its second-shaped face,

a step for forming a laser beam passing through said light transmission medium into a linear laser beam with a first length by at least one lens

a step for forming a linear laser beam with a second length by changing the length in the longitudinal direction of said linear laser beam with the first length by a slit; and

a step for making said linear laser beam with the second length irradiate to an object to be treated.

[Claim 11] A method for heat treating comprising:

a step for converting a laser beam emitted from a laser oscillator into a fundamental wave and a harmonic wave by a wavelength converter,

a step for forming said laser beam of the fundamental wave into a linear laser beam with a first length by a first lens,

a step for forming said laser beam of the harmonic wave into a linear laser beam with a second length by a second lens,

a step for forming a linear laser beam with a third length by changing the lengths in the longitudinal of said linear laser beam with the first length and said linear laser beam with the second

length by a slit; and

a step for making said linear laser beam with the third length irradiate to an object to be treated.

[Claim 12] A method for heat treating comprising:

a step for converting a laser beam emitted from a laser oscillator into a first harmonic wave and a second harmonic wave by a wavelength converter,

a step for forming said laser beam of the first harmonic wave into a linear laser beam with a first length by a first lens,

a step for forming said laser beam of the second harmonic wave into a linear laser beam with a second length by a second lens,

a step for forming a linear laser beam with a third length by changing the lengths in the longitudinal direction of said linear laser beam with the first length and said laser beam with the second length by a slit; and

a step for making said linear laser beam with the third length irradiate to an object to be treated.

[Claim 13] A method for heat treating wherein said laser oscillator is one laser selected from Nd:YAG laser, Nd:YVO_4 laser, and Nd:$YA1O_3$ laser in any one of claims 8 to 12.

[Claim 14] A method for manufacturing a semiconductor device comprising:

a process for forming a semiconductor film on a substrate,

a process for making a linear laser beam with a second length formed by shortening the length in the longitudinal direction of a linear laser beam with a first length by a slit irradiate to said semiconductor film; and

a process for forming a thin film transistor wherein a semiconductor film to which said linear laser beam with the second length is irradiated is an active layer.

[Claim 15] A method for manufacturing a semiconductor device comprising:

a process for forming a semiconductor film on a substrate,

a process for forming an island-shaped semiconductor film by etching said semiconductor film selectively,

a process for forming an impurity region by doping one-conductive impurity element into

one portion of said island-shaped semiconductor film,

a process for making a linear laser beam with a second length formed by shortening the length in the longitudinal direction of a linear laser beam with a first length by a slit irradiate at least to said impurity region; and

a process for forming a thin film transistor by using the impurity region to which said linear laser beam with the second length is irradiated.

[Claim 16] A method for manufacturing a semiconductor device comprising:

a process for forming a semiconductor film on a substrate,

a process for making a linear laser beam with a second length formed by shortening the length in the longitudinal direction of a linear laser beam with a first length by a slit irradiate to said semiconductor film,

a process for forming an island-shaped semiconductor film by etching said semiconductor film selectively,

a process for forming an impurity region by doping one-conductive impurity element into one portion of said island-shaped semiconductor film,

a process for making a linear laser beam with a second length formed by shortening the length in the longitudinal direction of said linear laser beam with the first length by a slit irradiate to at least said impurity region; and

a process for forming a thin film transistor by a semiconductor film to which said liner laser beam with the second length is irradiated and an impurity region which is formed on one portion of the semiconductor film.

[Claim 17] A method for manufacturing a semiconductor device comprising:

a process for forming a semiconductor film on a substrate,

a process for making a linear laser beam (A) and a linear laser beam (B) emitted from one laser oscillator and having different wavelengths respectively and of which lengths in the longitudinal direction are shortened by a slit irradiate to said semiconductor film simultaneously; and

a process for forming a thin film transistor wherein a semiconductor film to which said linear laser beam (A) and said linear laser beam (B) are irradiated is an active layer.

[Claim 18] A method for manufacturing a semiconductor device wherein a wavelength of said linear laser beam (A) is a fundamental wave of a laser beam emitted from said laser oscillator, and that of said linear laser beam (B) is a second harmonic wave or a third harmonic wave of a laser beam emitted from said laser oscillator in claim 17.

[Claim 19] A method for manufacturing a semiconductor device wherein a wavelength of said linear laser beam (A) is a second harmonic wave of a laser beam emitted from said laser oscillator, and that of said linear laser beam (B) is a third harmonic wave of a laser beam emitted from said laser oscillator in claim 17.

[Claim 20] A method for manufacturing a semiconductor device wherein one end in the longitudinal direction of said linear laser beam with the second length is irradiated to the inside of said substrate in any one of claims 14 to 16.

[Claim 21] A method for manufacturing a semiconductor device wherein one end in the longitudinal direction of said linear laser beam (A) and that of said linear laser beam (B) are irradiated to the inside of said substrate in any one of claims 17 to 19.

[Claim 22] A method for manufacturing a semiconductor device wherein said first laser beam is one laser beam emitted from Nd:YAG laser oscillator, Nd:YVO_4 laser oscillator, and Nd:$YA1O_3$ laser oscillator in any one of claims 14 to 21.

[Detailed Description of the Invention]

[0001]

[Field of the invention] The present invention relates to a method for heat treating of a semiconductor film by using a laser beam and an apparatus therefore (including a laser and an optical system for leading a laser beam output from the laser to an object to be treated). Furthermore, the present invention relates to a method for manufacturing a semiconductor device manufactured by a heat treating of a semiconductor film by using a laser beam. Besides, the semiconductor device in the present specification includes an electric optical device such as a liquid display device and an EL display device in which an electroluminescence (EL) material is used, and an electronic device including the electric optical device as parts.

[0002]

[Prior art] Recently, a thin film transistor (hereinafter referred to as TFT) in which a crystalline

semiconductor film typified by a poly-crystalline silicon film is used has been developed. TFT is used as a switching element provided in a pixel and an element which forms a driving circuit to control the pixel in a liquid crystal display device and an EL display device.

[0003] As a method for manufacturing a poly-crystalline silicon film, the technology of crystallizing a non-crystalline silicon film (an amorphous silicon film) is used generally. Especially, a method of crystallizing the amorphous silicon film by using a laser beam receives much attention. In the present specification, a laser crystallizing method means a method of obtaining a crystalline semiconductor film by which a semiconductor film is crystallized by heating with a laser beam among heat treating methods using the laser beam.

[0004] A laser crystallizing method by using a pulse laser beam, which performs crystallization by heating a semiconductor film instantaneously, is an effective technology as a method for crystallizing a semiconductor film formed on a substrate with low heat-resistance such as a glass substrate and a plastic one. Also, it is characterized by especially high throughput compared with a heating means by using the conventional furnace (hereinafter referred to as furnace annealing).

[0005] There are various kinds of laser oscillators. In general, a laser crystallizing method by using a laser beam of which oscillating source is a pulse oscillating type excimer laser (hereinafter referred to as an excimer laser) is used. The excimer laser has advantages of high output and high absorption coefficient for a silicon film. However, an oscillator is so large that it is necessary to refine gas for supplying and maintain discharge electrodes, consequently it requires some labor to maintain the apparatus.

[0006] On the other hand, it is under consideration that YAG laser of a solid laser is applied to the technology of laser crystallization. The wavelength of the fundamental wave of the YAG laser is 1064 nm, and its harmonic wave can be used. Especially, the YAG laser excited by a semiconductor laser can oscillates even in 10 kHz, and it has an advantage that irradiation can be repeated with high frequency like this.

[0007] By the way, a liquid crystal display device and an EL display device are usually manufactured by using glass as a substrate. TFT for forming a pixel and a driving circuit needs to be formed extending over large area on a glass substrate so that a method for treating the large area at short time is requested in order to improve the productivity in laser crystallization. At present, a

method is applied that a beam output from a laser is converted into a linear laser beam of which width is about 100 to 500 μm by an optical system so that it is irradiated to a semiconductor film. And then, a method is applied that all the surface of substrate is treated by scanning this linear laser beam in one-way.

[0008]

[Problems to be solved by the Invention] In order to correspond to the large-sized screen of a liquid crystal display device and an EL display device and produce a large number of display devices efficiently, a method for cutting out a plurality of substrates for display device from one large-scaled glass substrate is used. For example, when a display device of which screen size is 8 to 10 inch is manufactured, two substrates for display device can be cut out, if a glass substrate of 300 x 400 mm is used. In the future, taking a large-scaled screen size and increase of the number of substrates to be cut out into consideration, a large-scaled glass substrate of which one side is not less than 900 mm is under consideration.

[0009] However, in case of using a heat treating method by using a laser beam typified by a laser crystallizing method, when a linear laser beam which is irradiated to a semiconductor film formed on a substrate is made to be continuous length corresponding to a large-scaled glass substrate, a large-sized lens is necessary for the optical system so that a laser apparatus becomes large-scaled. Accordingly, production costs of the apparatus is increased, and also a laser oscillator with large output is needed correspondingly.

[0010] The present invention is a means for resolving such problems, and relates to a method and an apparatus for heat treating of a semiconductor film by using a laser beam in correspondence with a large-scaled substrate, a method for heat treating of a semiconductor film by using a laser beam, and a laser apparatus therefore (including a laser and an optical system for leading a laser beam output from the laser to an object to be treated). Furthermore, the present invention has the purpose to offer a method for manufacturing a semiconductor device manufactured by heat treating of a semiconductor film by using a laser beam.

[0011]

[Means for resolving the problems] The present invention, in a heat treating of a semiconductor film by using a laser beam, is characterized by changing the length of a linear laser beam timely by

providing a slit for adjusting the length in the longitudinal direction of the laser beam treated to a linear shape by an optical system. Treating a laser beam into a linear shape means that the laser beam is treated as a shape of irradiated face becomes a linear shape, when the laser beam is irradiated to an object to be treated. That is to say, it means that a cross-sectional shape of the laser beam is processed to a linear shape. Besides, the linear shape referred to as here does not mean a line in the strict sense of the word, but a rectangle (or oblong) with high aspect ratio. For example, it indicates the rectangle of which aspect ratio is not less than 10 (preferably 100 to 1000).

[0012] The constitution of the present invention is explained by Figure 1. A substrate 801, of which size is not regulated, presupposes that a plurality of panels are taken out from one substrate. Figure 1 shows an example of dividing the substrate 801 into six and taking out substrates 802a to 802f for forming display devices wherein a pixel portion formed by TFT and its driving circuit makes one unit. In Figure 1, a pixel portion 803a, driving circuits 803b and 803c, and the other signal processing circuit 803d are formed on the portions shown by dotted lines on the substrate 802a for forming a display device (in the same way as 802b to 802f). Besides, the number of taking out from one substrate is not limited especially, and the constitution and arrangement of the pixel portion and the driving circuit are also decided suitably.

[0013] A heat treating method of a semiconductor film by using a laser of the present invention is performed by which a linear laser beam with a first length formed by an optical system is converted by a slit 800 into a linear laser beam with a second length and is irradiated to a substrate 801. The slit is composed integrally of a base 804 and a movable plate 805, and the length in the longitudinal direction of the linear laser beam is regulated by the movable plate 805. The movable plate 805 can be fixed to the base 804, however, if a function to make it variable on the base 804 is added, the length in the longitudinal direction of the linear laser beam can be changed to a desired length within a variable range.

[0014] In this way, a region to be irradiated 808 by a linear laser beam with a second length 807 is formed on the substrate 801. In Figure 1, the length in the longitudinal direction in the region to be irradiated 808 is W, the length of a region in which a pixel portion 803a of a substrate 802a for forming a display device, driving circuits 803b and 803c and other signal processing circuit 803d are formed is X1, the length of one way of the substrate 802a for forming the display device is X2,

and the length from one end of the substrate 802a for forming the display device, to the region for forming a pixel portion, a driving circuit and other signal processing circuit of a substrate 802d for forming the adjacent display device is X3. In the constitution of the present invention, it is preferable that the suitable value of W is more than X1, less than X3, and nearly equal to X2.

[0015] A heat treating of a semiconductor film by using a laser beam (laser crystallization in this case) can be performed on the substrates 802a to 802f for forming the display device provided on the substrate 801 by shifting a linear laser beam with the length of W like this and the substrate 801 relatively in the direction crossing with the longitudinal direction.

[0016] The length of a region to be irradiated 808 (that is to say, a linear laser beam with a second length 807) is not regulated particularly, it can be formed so as to be nearly equal to the length of one side of a region for forming a display device as shown in Figure 1, besides so as to correspond to the size of the pixel portion 803a and the driving circuits 803b and 803c.

[0017] Besides, the heat treating of a semiconductor film by using a laser beam in the present invention covers the whole treatments that the semiconductor film is heated by which the laser beam is irradiated, and includes a laser crystallizing method that the semiconductor film is crystallized by heating with a laser beam so that a crystalline semiconductor film is obtained, a treating for the purpose of rearranging atoms of the semiconductor film, and a treating of activating one-conductive impurity doped to the semiconductor film.

[0018] Therefore, a laser apparatus of the present invention is characterized by comprising a laser oscillator; at least one lens for forming a laser beam emitted from said laser oscillator into a linear laser beam with a first length; a slit for forming a linear laser beam with a second length by changing the length in the longitudinal direction of said linear laser beam with the first length; and a treating chamber in which said linear laser beam with the second length is irradiated to an object to be treated.

[0019] Besides other constitution is characterized by comprising a laser oscillator; a step-shaped mirror for reflecting a laser beam emitted from said laser oscillator, and at least one lens for forming the laser beam reflected with said mirror into a linear laser beam with a first length; a slit for forming a linear laser beam with a second length by changing the length in the longitudinal direction of said linear laser beam with the first length; and a treating chamber in which said linear

laser beam with the second length is irradiated to an object to be treated.

[0020] Besides other constitution is characterized by comprising a laser oscillator; a micro lens array for condensing a laser beam emitted from said laser oscillator; a light transmission medium for making a laser beam passing through said micro lens array incident from a face of a first shape and for emitting it from a face of a second shape; at least one lens for forming the laser beam passing through said light transmission medium into a linear laser beam with a first length; a slit for forming a linear laser beam with a second length by changing the length in the longitudinal direction of said linear laser beam with the first length; and a treating chamber in which said linear laser beam with the second length is irradiated to an object to be treated. An optical fiber array can be used as light transmission medium.

[0021] Besides other constitution is characterized by comprising a laser oscillator; a wavelength converter for converting a laser beam emitted from said laser oscillator into a fundamental wave and a harmonic wave; a first lens for forming the laser beam of said fundamental wave into a linear laser beam with a first length; a second lens for forming the laser beam of said harmonic wave into a linear laser beam with a second length; a slit for forming a linear laser beam with a third length by changing the lengths in the longitudinal direction of said linear laser beam with the first length and said linear laser beam with the second length; and a treating chamber in which said linear laser beam with the third length is irradiated to an object to be treated.

[0022] Besides other constitution is characterized by comprising a laser oscillator; a wavelength converter for converting a laser beam emitted from said laser oscillator into a first harmonic wave and a second harmonic wave; a first lens for forming said laser beam of the first harmonic wave into a linear laser beam with a first length; a second lens for forming said laser beam of the second harmonic wave into a linear laser beam with a second length; a slit for forming a linear laser beam with a third length by changing the lengths in the longitudinal direction of said linear laser beam with the first length and said linear laser beam with the second length; and a treating chamber in which said linear laser beam with the third length is irradiated to an object to be treated.

[0023] In the present invention, a laser which is well known to a public can be used. YAG laser (generally referred to as Nd:YAG laser), Nd:YVO_4 laser, Nd:$YA1O_3$ laser, ruby laser, Ti: sapphire laser, glass laser, etc. can be used. Especially, YAG laser which is superior in coherency and pulse

energy is preferable. However, because a fundamental wave (a first harmonic wave) of YAG laser has a long wavelength of 1064 nm, it is preferable that a third harmonic wave (wavelength is 355 nm) or a fourth harmonic wave (wavelength is 266 nm) is used. As the case may be, a second harmonic wave (wavelength is 532 nm) can be used. These harmonic waves can be obtained by using nonlinear crystal.

[0024] The first harmonic wave can be modulated to the second harmonic wave, the third one and the fourth one by a wavelength modulator containing a nonlinear element. Forming each harmonic wave can be guided by the widely known technology. Also, in the present specification, "a laser beam of which oscillating source is a solid laser" includes not only the first harmonic wave but also the second harmonic wave, the third one and the fourth one of which wavelength are modulated on the way. Besides, Q switching method (Q modulation switching method) used frequently in YAG laser can be used. This is a method that a steep pulse laser with extreme high energy value is output by increasing Q value suddenly from the condition that Q value of a laser sympathetic vibrator is kept low enough. This is the widely known technology.

[0025] A heat treating method by using a laser beam of the present invention wherein a laser apparatus like this is used is characterized by comprising a step for forming a laser beam emitted from a laser oscillator into a linear laser beam with a first length by at least one lens; a step for forming a linear laser beam with a second length by changing the length in the longitudinal direction of said linear laser beam with the first length by a slit; and a step for making said linear laser beam with the second length irradiate to an object to be treated. A step for reflecting said laser beam with a step-shaped mirror can be added between said laser oscillator and said lens.

[0026] Besides other constitution of the invention is characterized by comprising; a step for condensing a laser beam emitted from a laser oscillator with a micro lens array; a step for making a laser beam passing through said micro lens array incident from a first shaped face of light transmission medium and for emitting it from a second shaped face of that one; a step for forming the laser beam passing through said light transmission medium into a linear laser beam with a first length by at least one lens; a step for forming a linear laser beam with a second length by changing the length in the longitudinal direction of said linear laser beam with the first length by a slit; and a step for making said linear laser beam with the second length irradiate to an object to be treated.

[0027] Besides other constitution of the invention is characterized by comprising; a step for converting a laser beam emitted from a laser oscillator into a laser beam with a first wavelength and that one with a second wavelength by a wavelength converter; a step for forming said laser beam with the first wavelength into a linear laser beam with a first length by a first lens; a step for forming said laser beam with the second wavelength into a linear laser beam with a second length by a second lens; a step for forming a linear laser beam with a third length by changing the lengths of said linear laser beam with the first length and said linear laser beam with the second length by a slit; and a step for making said linear laser beam with the third length irradiate to an object to be treated. The laser beam with the first wavelength and that one with the second wavelength can be any combination of wavelength, but the beam source is one laser oscillator. Therefore, the combination of the first wavelength and the second wavelength can be the combination of two wavelengths selected from the fundamental wave, the second harmonic wave, and the third one.

[0028] A manufacturing method of a semiconductor device of the present invention is characterized by comprising; a process for forming a semiconductor film on a substrate; a process for making a linear laser beam with a second length formed by shortening the length in the longitudinal direction of a linear laser beam with a first length by a slit irradiate to said semiconductor film; and a process for forming a thin film transistor wherein the semiconductor film to which said linear laser beam with the second length is irradiated is an active layer.

[0029] Besides other constitution of the invention is characterized by comprising; a process for forming a semiconductor film on a substrate; a process for forming an island-shaped semiconductor film by etching said semiconductor film selectively; a process for forming an impurity region by doping one-conductive impurity element into one portion of said island-shaped semiconductor film; a process for making a linear laser beam with a second length formed by shortening the length in the longitudinal direction of a linear laser beam with a first length by a slit irradiate at least to said impurity region; and a process for forming a thin film transistor by using the impurity region to which said linear laser beam with the second length is irradiated.

[0030] Besides other constitution of the invention is characterized by comprising; a process for forming a semiconductor film on a substrate; a process for making a linear laser beam with a second length formed by shortening the length in the longitudinal direction of a linear laser beam with a

first length by a slit irradiate to said semiconductor film; a process for forming an island-shaped semiconductor film by etching said semiconductor film selectively; a process for forming an impurity region by doping one-conductive impurity element into one portion of said island-shaped semiconductor film; a process for making a linear laser beam with a second length formed by shortening the length in the longitudinal direction of said linear laser beam with the first length by a slit irradiate at least to said impurity region; and a process for forming a thin film transistor by the semiconductor film to which said liner laser beam with the second length is irradiated and the impurity region which is formed on one portion of the semiconductor film.

[0031] Besides other constitution of the invention is characterized by comprising; a process for forming a semiconductor film on a substrate; a process for making a linear laser beam (A) and a linear laser beam (B) emitted from one laser oscillator and having different wavelengths respectively and of which lengths in the longitudinal direction are shortened by a slit irradiate to said semiconductor film simultaneously; and a process for forming a thin film transistor wherein a semiconductor film to which said linear laser beam (A) and said linear laser beam (B) are irradiated is an active layer.

[0032]

[Embodiment] [Embodiment mode 1] One of the embodiment modes of the present invention is explained. Figure 2 shows a constitution of a laser apparatus including a laser of the present invention. This laser apparatus is constituted by a laser oscillator 811, an optical system 810 which treats a laser beam (preferably a third harmonic wave or a fourth harmonic wave) of which oscillating source is the laser oscillator 811 into a linear shape, and a stage 812 which fixes and shifts a substrate 813. A laser beam 814 which is formed into a linear shape by the optical system 810 is irradiated to the substrate 813 on the stage 812.

[0033] As the laser oscillator 811, the Nd:YAG laser is used suitably. The Nd:YAG laser can be excited by a lamp, however in order to realize higher output and high oscillating frequency, preferably it is excited by a semiconductor laser. Besides, when a laser beam output from the laser oscillator 811 is modulated into any one of the second harmonic wave to the fourth one, a wavelength modulator containing nonlinear element can be provided just after the laser oscillator 811.

[0034] Next, in a laser apparatus having a constitution like Figure 2, an example of an apparatus treating the substrate 813 is explained with Figure 3. The substrate 813 held on the stage 812 is set in a treating chamber (A) 818, to which a linear laser beam of which oscillating source is the laser oscillator 811 shown in Figure 2 is irradiated. The inside of a reaction chamber can be a low pressure condition or an atmosphere of inert gas by exhausting system or gas system which are not shown in the Figure, and a heating means which can heat a semiconductor film up to 100 to 450 ℃ without contamination is provided on a stage 825. Besides, the stage 825 corresponds to the stage 812 shown in Figure 2.

[0035] Besides, the stage 825 can be shifted along a guide rail 821 in the reaction chamber, and a linear laser beam can be irradiated on all the surface of substrate. The laser beam is incident from a window not shown in the Figure, which is made of quartz and provided on the upper face of the substrate 826. Also, this reaction chamber 818 is connected to a transfer chamber 815 through a partition valve 824 in Figure 3. Moreover, the transfer chamber 815 is connected to a load and unload chamber 817 through a partition valve 822, and a treating chamber (B) 816 for forming a coating film through a partition valve 823.

[0036] A cassette 819 which can hold a plurality of substrates is set in the load and unload chamber 817, and constitutively the substrates are transferred by a transferring means 820 provided in the transfer chamber 815. A substrate 827' is a substrate in transferring. The treating chamber (B) 816 is for forming a semiconductor film by plasma CVD, sputtering, etc., wherein a gas supplying means which is not shown in Figure is provided, in addition to a substrate heating means 828 and a glow discharge generating means 829.

[0037] It is not shown in Figure 3, by providing an exhausting means and a gas supplying means in the transfer chamber 815, the treating chamber (A) 815, the treat chamber (B) 816, and the load and unload chamber 817, formation of a semiconductor film and heat treating of the semiconductor film by using a laser beam can be performed continuously under low pressure condition or in an atmosphere of inert gas.

[0038] The constitution of an optical system 810 which makes a laser beam into linear shape is explained with Figure 4. Figure 4 (A) is a side view of the optical system 810, and Figure 4 (B) is a upper side view of the optical system 810.

[0039] A laser oscillator 301 is the same as the laser oscillator 811 shown in Figure 2, from which the laser beam output is divided in the longitudinal direction by a cylindrical lens array 302. This divided laser beam is furthermore divided in the horizontal direction by a cylindrical lens 303. That is to say, the laser beam is divided into a matrix shape finally by the cylindrical lens arrays 302 and 303.

[0040] And then, the laser beam is condensed once by a cylindrical lens 304. On this occasion, it passes through a cylindrical lens 305 just after the cylindrical lens 304. Subsequently, after it is reflected by a mirror 307 and passes through a cylindrical lens 308, it goes through a slit 309 and reaches an irradiated face 310.

[0041] At this time, the laser beam projected on the irradiated face 310 shows the linear irradiated face. That is to say, it means that a cross section of the laser beam transmitting through the cylindrical lens 308 is a linear shape. The slit 309, as explained in Figure 1, is for regulating the length in the longitudinal direction of the linear laser beam. Homogenization of this laser beam treated into linear shape in the width direction (the short direction) is performed by the cylindrical lens array 302, and the cylindrical lenses 304 and 308. Besides, homogenization of the above laser beam in the longitudinal direction (the long direction) is performed by the cylindrical lens array 303 and the cylindrical lens 305.

[0042] Each lens composing an optical system 810 is coated suitably to increase the transmittance adjusting to the wavelength of the laser beam. Accordingly it is preferable that the energy efficiency is increased, and the life of lens can be lengthened..

[0043] [Embodiment mode 2] Other constitution of the optical system 810 which makes the laser beam shown in Figure 2 into linear shape is explained with Figure 5. Figure 5 (A) is a side view of the optical system 810, and Figure 5 (B) is an upper side view of the optical system 810.

[0044] In Figure 5, a laser beam emitted from a laser oscillator 501, of which direction of advance is varied by a mirror 502, and of which shape is converted by a beam expander 503. The beam expander 503 is constituted by the combination of cylindrical lenses 514 and 515. The laser beam passing through the beam expander 503 is reflected by a step-shaped mirror 504 and is incident on a cylindrical lens array 505. At this time, it is incident with an optical path difference d to two adjacent cylindrical lenses. The length of said optical path difference d is not less than the

coherent length of the laser oscillator 501. For example, because the coherent length of YAG laser oscillator is about 1 cm, the interference can be restrained on an irradiated face 511 if the optical path difference d is 1 cm.

[0045] The optical path difference d can be adjusted by adjusting the height of a step of the step-shaped mirror 504. For example, the number of steps of the step-shaped mirror 504 is five, the width of each step is 14 mm, and the height thereof is 7 mm. In case that the laser beam is incident on said step-shaped mirror from the direction that the width of shadow on each step is 7 mm when a beam parallel to said step-shaped mirror is incident, the laser beam reflected by each step of stairs is incident with 1 cm of the optical path difference on two adjacent cylindrical lenses which form a cylindrical array lens 505. The laser beams reflected by each step of stairs of the step-shaped mirror 504, which become laser beams with the width of 5 mm respectively, are incident on the cylindrical lenses one by one which form the cylindrical array lens 505. The width of the cylindrical array lens 505 is decided by a shape of step-shaped mirror, in this case, the width of each cylindrical lens which form the cylindrical array lens 505 is 15 mm.

[0046] The laser beams reflected by the step-shaped mirror, the cylindrical lens array 505 is a flat convex lens and the curved surface of convex is spherical. The laser beam is incident from the spherical side. The cylindrical lens array 505 as shown in Figure 5 (B) performs the part of dividing the laser beam in the horizontal direction. The divided laser beam is incident on a cylindrical lens 506. The cylindrical lens 506 performs the part of making the laser beams divided in the horizontal direction into one beam on an irradiated face 611. Accordingly, the linear laser beam is made to be uniform in the longitudinal direction and the length of the linear laser beam is decided.

[0047] Next, the constitution of optical system which affects on the vertical direction is described with Figure 5 (A). A laser beam going through a cylindrical lens array 506 is incident on a cylindrical lens array 507a, which is away from the cylindrical lens array 506. The laser beam is divided in the vertical direction by this cylindrical lens array 507a. The laser beam going through the cylindrical lens array 507a is incident on a cylindrical lens array 507b, which is away from the cylindrical lens array 507a. The laser beam divided by the cylindrical lens array 507a is incident on a cylindrical lens 508. An incident face of the laser beam of the cylindrical lens 508 is the plane

side of a flat convex lens. The laser beams are once condensed into one beam on the same face by the cylindrical lens 508. Said same face is positioned on the focus of the cylindrical lens 508. Said same face is on the way of an optical path so that the laser beam is separated again.

[0048] The laser beam going through the cylindrical lens 508 is incident on a cylindrical lens 509, which is away from the cylindrical lens 508. A doublet cylindrical lens can be used as the cylindrical lens 509. With regard to the arrangement of lens, a mirror 513 can be inserted between the cylindrical lens 508 and the doublet cylindrical lens 509. Accordingly, the direction of the laser beam can be changed to below. The laser beams divided in the vertical direction are made into one beam on an irradiated face 511. Accordingly, the linear laser beam is made to be uniform in the width direction. Besides, the length of width of the linear laser beam is decided.

[0049] When the energy distribution in the linear direction of linear laser beam is within $\pm 5\%$, the homogeneous heat treating can be performed to a semiconductor film. Preferably $\pm 3\%$, more preferably $\pm 1\%$, more homogeneous heat treating can be performed. Precise alignment of lens is needed to make the energy distribution uniform.

[0050] [Embodiment mode 3] A method for forming a linear laser beam with a plurality of lens by the optical system 810 shown in Figure 2 is shown in embodiment modes 1 and 2. In the present embodiment mode, the constitution of other optical system is shown. Figure 6 (A) is a side view of the optical system 810, and Figure 6 (B) is an upper side view of the optical system 810.

[0051] A laser oscillator 401 in Figure 6 is the same as the laser oscillator 811 explained in embodiment mode 1. It is preferable that a laser beam emitted from the laser oscillator 401 is a fundamental wave or a second harmonic wave of YAG laser, and it is incident on a light transmission medium 403 through a micro lens array 402. An antireflector 404 is provided on the light incident side of the light transmission medium 403.

[0052] The light incident side and the light emitting side of the light transmission medium 403 have different areas or shapes, or areas and shapes respectively. For example, the shape of light incident side is a circle or an oval, and the shape of beam emitting side is a rectangle or an oblong. Also, the ratio of area (the light incident side : the light emitting side) is about 1 : 1 to 1 : 100. Such constitution of the light transmission medium 403 can makes the shape of laser beam emitted from the light emitting side into rectangle or oblong.

[0053] An example of the light transmission medium 403 is shown in Figure 7. The example that the light transmission medium is formed by an optical fiber array 701 comprising a plurality of optical fibers is shown in Figure 7 (A). The light incident side is formed to be circle, and the light emitting side is formed to be rectangle, and the area of the light emitting side is larger than that of the light incident side. For that reason, the sectional area of each optical fiber 704 which forms the optical fiber array 701 is formed gradually larger from the light incident side. In case of such constitution, the area ratio of the light incident side to the light emitting side can be about 1 : 100. On the other hand, in Figure 7 (B), the area ratio of the light incident side to the light emitting side of the optical fiber array 705 is 1 : 1, the light incident side 706 is circle,
and the light emitting side 707 is rectangle, of which length ratio of the short sides to the long sides is 1 :10 to 1 : 1000. The sectional area of each optical fiber 708 which forms the optical fiber array 705 is the same. Of course, a constitution that a sectional area is changed as Figure 7 (A) can be used.

[0054] The laser beam of which beam shape is changed by the light transmission medium 403 is condensed by the cylindrical lens 406, and becomes a linear laser beam on the irradiated face 408. A slit 407 having the same constitution as that one shown in Figure 1 is provided between the cylindrical lens 406 and the irradiated face 408, so that the length in the longitudinal direction of the linear laser beam is fixed. In this way, owing to use the light transmission medium 403, a low-priced optical system can be constituted by omitting the cylindrical lens array shown in Figures 4 and 5.

[0055] [Embodiment mode 4] In the present embodiment mode, as an optical system 810 is shown in Figure 8, an example is shown that laser beams of two system, wherein a laser beam emitted from a laser oscillator 601 is divided into a fundamental wave and a second harmonic wave, or a second harmonic wave and a third one on the way of an optical system, are made into linear laser beams respectively, and are piled on an irradiated face 614 and irradiated.

[0056] Figure 8 is a side view of an optical system of a laser apparatus used in the present embodiment mode. A laser beam of which source is an Nd: YAG laser 601 is converted into a fundamental wave and a second harmonic wave, or the second harmonic wave and a third one by a wavelength converter 602, and the laser beams with respective wavelength are irradiated toward a

half mirror 603. A mirror wherein one laser beam is transmitted, and the other one is reflected is used as the half mirror 603.

[0057] First, the laser beam transmitting the half mirror 603 is formed into a linear laser beam 612 by cylindrical lenses 605, 607 and 609. Besides, the laser beam reflected by the half mirror 603 is formed into a linear laser beam 613 by cylindrical lenses 606, 608 and 610.

[0058] The linear laser beams 612 and 613 are piled on an irradiated face 614 and irradiated on the same region. A slit 611 having the same constitution as that one shown in Figure 1 is provided between the cylindrical lenses 609/610 and the irradiated face 614, so that the length in the longitudinal direction of the linear laser beam is fixed.

[0059] In this way, by making use of the difference of light absorbing characteristic of a semiconductor film by varying the wavelength of the linear laser beam irradiated on the irradiated face 614, a heat treating wherein one linear laser beam mainly heats a substrate by transmitting the semiconductor film, the other one heats the semiconductor film by being absorbed with the semiconductor film can be performed.

[0060] [Embodiment mode 5] Figure 5 is a view showing one example of heat treating of a semiconductor film by using a laser beam of the present invention. In Figure 5 (A), an alkali free glass substrate such as barium borosilicate glass, aluminoborosilicate glass, etc. is used as a substrate 1001. For example, #7059 glass, #1737 radical glass, etc. of Corning can be used suitably. Besides, a quartz substrate and a plastic substrate having no optical anisotropy such as polyethylene terephthalate (PET), polyethylene naphthalate (PEN), polyethersulfone (PES), etc. can be used. An insulating film 1002 containing silicon such as a silicon oxide film, a silicon nitride film, silicon oxide nitride (SiOxNy) film, etc. is formed to a thickness of 100 to 300 nm on the surface of the substrate 501 for forming an island-shaped semiconductor film in order to prevent diffusion of impurity such as alkali metal element etc. from the substrate 1001. This insulating film 1002 can be formed with one layer of a film containing said silicon, or with lamination of a plurality of films. For example, an oxide nitride silicon film made from SiH_4, NH_3, N_2O by plasma CVD method is used.

[0061] An amorphous semiconductor film 1003 having amorphous structure is formed to a thickness of 25 to 80 nm (preferably 30 to 60 nm) on the insulating film 1002 by the widely known

method such as plasma CVD method and sputtering. For example, an amorphous silicon film is formed to a thickness of 55 nm by plasma CVD method. An amorphous semiconductor film and a fine crystalline semiconductor film are included in semiconductor films having amorphous structure, and a compound semiconductor film having amorphous structure such as an amorphous silicon germanium film can be used.

[0062] Next, as shown in Figure 5 (B), crystallization is performed by using any one of heat treating methods of a semiconductor film by using laser beam shown in embodiment modes 1 to 3. The constitution of apparatus used in laser crystallization that is the same as that one explained in Figures 2 to 7 is applied. First for crystallization, it is desirable that hydrogen contained in the amorphous semiconductor film is discharged, accordingly it is preferable that the quantity of hydrogen-containing is made to be not more than 5 atom% by performing heat treating at 400 to 500℃ for about one hour.

[0063] The conditions of laser crystallization are selected by performers properly, for example, the pulse oscillating frequency of Nd: YAG laser is 10 kHz, the laser energy density is 200 to 500 mJ/cm^2 (typically 300 to 450 mJ/cm^2), and an amorphous semiconductor film is crystallized by scanning a linear laser beam in the vertical direction to the longitudinal direction (or a substrate is shifted relatively). The linear width of the linear laser beam is 100 to 1000 μm, for example, a linear laser beam 1005 of 400 μm is irradiated. A slit 1004 having the same constitution as that one explained in Figure 1 is provided on the substrate 1001, and regulates the length in the longitudinal direction of the linear laser beam. Only one portion of the amorphous semiconductor film 1003 can be crystallized by providing the slit 1004 like this.

[0064] The same place is irradiated by linear beam like this at a plurality of times. Or it is irradiated at a plurality of times with the linear beam scanning. It is preferable that the overlap rate (the overlap rate) of linear beam at this time is 90 to 99%. Actually, it is preferable that the number of irradiation pulse is 10 to 40 pulse. It is effective for high crystallinity of the amorphous semiconductor film that the same region is irradiated repeatedly with high overlap rate. Generally, the treating time becomes longer if the overlap rate is increased, consequently the throughput is reduced. However, when YAG laser oscillator excited by a semiconductor laser is used, the oscillating frequency can be increased like the present embodiment mode, accordingly the

throughput is not reduced. In this way, the crystalline semiconductor film 1006 is formed.

[0065] Besides, Figure 10 follows the method shown in the embodiment mode 4, and is an example of forming a crystalline semiconductor film 1009 by which two wavelengths selected from a fundamental wave, a second harmonic wave, and a third harmonic wave of YAG laser are irradiated through a slit 1004.

[0066] For example, a linear laser beam 1007 is a fundamental wave (wavelength 1064 nm) and a linear laser beam 1008 is a second harmonic wave (wavelength 532 nm). When an amorphous semiconductor film 1003 is an amorphous silicon film, advantages are brought that the linear laser beam 1007 transmits the amorphous silicon film and reaches a substrate 1001, so that the amorphous silicon film is heated by the substrate 1001 of the irradiated region consequently crystallization of the amorphous silicon film is promoted. On the other hand, the linear laser beam 1008 is converted into heat by being absorbed partially with the amorphous silicon film so that it contributes to crystallization directly. When the laser energy density of linear laser beam 1008 is not less than 300 mJ/cm^2, the amorphous silicon film can be dissolved so that crystallization can be performed easily.

[0067] [Embodiment mode 6] In the present embodiment mode, other embodiment mode of forming a crystalline semiconductor film by applying a crystallizing method with catalytic element which is disclosed in Japanese Patent Application Laid-open No. Hei 7-130652 is explained by Figure 11.

[0068] As shown in Figure 11 (A), in the same way as the embodiment mode 5, undercoating films 1102a and 1102b, and a semiconductor film 1103 having amorphous structure are formed to a thickness of 25 to 80 nm on a glass substrate 1101. As an amorphous semiconductor film, an amorphous silicon (a-Si) film, an amorphous silicon germanium (a-SiGe) film, an amorphous silicon carbide (a-SiC) film, an amorphous silicon tin (a-SiSn) film, etc. can be used. It is preferable that these amorphous semiconductor film are formed so as to contain hydrogen of about 0.1 to 40 atomic%. For example, an amorphous silicon film is formed to a thickness of 55 nm. And then, a layer 1104 containing catalytic element is formed by spin coat method that solution containing catalytic element of 10 ppm by weight conversion is coated by rotating the substrate with a spinner. Catalytic element are nickel (Ni), germanium (Ge), iron (Fe), palladium (Pd), tin (Sn),

zinc (Pb), cobalt (Co), platinum (Pt), copper (Cu), gold (Au), etc. As the layer 1104 containing this catalytic element, a layer of the above catalytic element can be formed to a thickness of 1 to 5 nm by printing, spray method, barcoater method besides spin coat method, or sputtering, and vacuum evaporation method.

[0069] And then, in a process for crystallization shown in Figure 11 (B), first a heat treating is performed at 400 to 500 ℃ for about one hour so that the quantity of hydrogen-containing of the amorphous silicon film is made to be not more than 5 atom%. If the quantity of hydrogen-containing of the amorphous silicon film is this value from the beginning after deposition, this heat treating is not always necessary. Next, heat crystallization is performed at 550 to 600 ℃ in a nitrogen atmosphere for 1 to 8 hours by using a furnace for furnace annealing. The crystalline semiconductor film 1105 made of the crystalline silicon film can be obtained by the processes mentioned above (Figure 11 (B)).

[0070] However, when the crystalline semiconductor film 1105 manufactured by this heat crystallization is observed in broad perspective by an optical microscope, it is sometimes observed that the amorphous region remains locally, in this case, an amorphous ingredient having a broad peak at 480 cm^{-1} is observed by Raman spectroscopy in the same way. Therefore, as explained in the embodiment mode 5 after thermal annealing, it can be applied as an effective means that the crystallinity is heightened by which a linear laser beam is irradiated to the crystalline semiconductor film 1105 by using any one of heat treating methods of a semiconductor film by using a laser beam shown in the embodiment modes 1 to 4.

[0071] Figure 11 (C) shows the situation, for example, the pulse oscillating frequency of Nd: YAG laser is 1 to 10 kHz, the laser energy density is 100 to 500 mJ/cm^2 (typically 100 to 400 mJ/cm^2) and a linear laser beam 1107 is scanned (or the substrate is shifted relatively) in the vertical direction to the longitudinal direction. The width of linear laser beam 1107 is 100 to 1000 μm, for example 400 μm. A slit 1106 is provided at this time, and regulates the length in the longitudinal direction of the linear laser beam.

[0072] Thus, a crystalline semiconductor film with high crystallinity can be formed by heat treating method by using heat crystallization and a laser beam of the present invention. Besides, by regulating the length in the longitudinal direction of the linear laser beam 1107 with the slit 1106,

the linear laser beam is irradiated easily to a substrate of which one side is at least longer than the length in the longitudinal direction of the linear laser beam.

[0073] [Embodiment mode 7] Figure 12 shows an example wherein a heat treating method of a semiconductor film by using a laser beam of the present invention is applied to an activation treating of a semiconductor film to which one-conductive type impurity element is doped.

[0074] Figure 12 (A) shows the situation wherein a substrate 1301, a first insulating film 1302, an island-shaped semiconductor film 1303, and a second insulating film 1304 are formed. It is desirable that the island-shaped semiconductor film 1303 is made from a crystalline semiconductor film manufactured in the embodiment modes 5 or 6. Doping of one-conductive type impurity element 1307 is performed by the ion doping method and ion implanting method that said impurity element is ionized, accelerated in the electric field and implanted into a semiconductor film. If a mask 1306 is formed on the second insulating film at that time, an impurity region 1308 can be formed selectively on the island-shaped semiconductor film 1303. The mask 1306 can be any one of a resist, a conductive film or an insulating film, and it is suitable that it has an effect of screening said ionized impurity element to the island-shaped semiconductor film 1303 of the lower layer.

[0075] Because one-conductive type impurity element doped in Figure 12 (A) rarely functions as a donor or an acceptor as it is, a treating for activation is performed generally. This treating can be performed by thermal annealing with a furnace for furnace annealing, besides, it is suitable that the heat treating method of a semiconductor film by using a laser beam of the present invention is used.

[0076] Figure 12 (B) is an example of using the heat treating method shown in the embodiment mode 4, wherein the heat treating is performed on the island-shaped semiconductor film 1303 by which two wavelengths selected from a fundamental wave, a second harmonic wave and a third harmonic wave of YAG laser are irradiated synchronously through a slit 1309.

[0077] For example, a linear laser beam 1310 is a fundamental wave (wavelength 1064 nm), and a linear laser beam 1311 is a second harmonic wave (wavelength 532 nm). The activation of the impurity region 1308 can be performed effectively by the multiplier effect of these two linear laser beams. That is to say, the linear laser beam 1310 reaches the substrate 1301, and is useful for heating the island-shaped semiconductor film 1303 from the substrate 1301 side of the irradiated region. Also, the linear laser beam 1311 irradiated on the impurity region 1308 is absorbed

partially with the impurity region 1308 and is converted into heat so that it contributes to activation directly. When the laser energy density of the linear laser beams 1310 and 1311 is not more than 300 mJ/cm^2, it is possible to dissolve the island-shaped semiconductor film 1303 so that the activation can be performed easily. Besides, by regulating the length in the longitudinal direction of the linear laser beams 1310 and 1311 by the slit 1309, the linear laser beams can be irradiated easily to a substrate of which one side is at least longer than the length in the longitudinal direction of the linear laser beams. Of course, the same effect can be obtained if the heat treating method shown in the embodiment modes 1 to 3 is applied to this embodiment mode.

[0078] [Embodiment 1] The present embodiment shows processes for manufacturing a display device, and a method for manufacturing a pixel TFT and a storage capacity of a pixel portion, and TFT of a driving circuit provided around a display region simultaneously is explained in detail according to the processes with Figures 13 to 15.

[0079] In Figure 13 (A), as a substrate 101, a plastic substrate having no optical anisotropy such as polyethylene terephthalate (PET), polyethylene naphthalate (PEN), polyethersulfone (PES), etc. can be used, in addition to a glass substrate such as barium borosilicate glass, aluminoborosilicate glass, etc. which is typified by #7059 glass, #1737 radical glass, etc. of Corning. In case of using a glass substrate, the heat treating can be performed in advance at low temperature which is lower by about 10 to 20 ℃ than glass distortion spot. And then, in order to prevent the impurity diffusion from the substrate 101, an undercoating film 102 made of an insulating film such as a silicon oxide film, a silicon nitride film, a silicon oxide nitride film, etc. is formed on the surface of the substrate 101 for forming TFT. For example, a silicon oxide nitride film 102a made from SiH_4, NH_3 and N_2O by plasma CVD method is formed to a thickness of 10 to 200 nm (preferably 50 to 100 nm), and a silicon oxide nitride hydride film 102 b made from SiH_4 and N_2O is formed to a thickness of 50 to 200 nm (preferably 100 to 150 nm) in the same way and laminated thereon.

[0080] The silicon oxide nitride film is formed by plasma CVD method of parallel and flat type. The silicon oxide nitride film 102a is formed by introducing SiH_4 of 10 SCCM, NH_3 of 100 SCCM, and N_2O of 20 SCCM into a reaction chamber, the substrate temperature is 325 ℃, the reaction pressure is 40 Pa, the discharge electric density is 0.41 W/cm^2, and the discharge frequency is 60 MHz. On the other hand, the silicon oxide nitride hydride film 102b is formed by introducing

SiH_4 of 5 SCCM, N_2O of 120 SCCM, and H_2 of 125 SCCM into a reaction chamber, the substrate temperature is 400 ℃, the reaction pressure is 20 Pa, the discharge electric density is 0.41 W/cm^2, and the discharge frequency is 60 MHz. These films can be formed in series only by changing the substrate temperature and switching the reaction gases.

[0081] The silicon oxide nitride film 102a manufactured under the above conditions, of which density is $9.28 \times 10^{22}/cm^3$ and etching rate of the mixed solution (Stella Chemifa Corp., a brand name LAL 500) containing ammonium hydrogen fluoride (NH_4HF_2) of 7.13 % and ammonium fluoride (NH_4F)of 15.4 % at 20 ℃ is slow about 63 nm/min, is a dense and solid film. When such film is used as an undercoating film, it is effective that a semiconductor film formed on this film is prevented from diffusion of alkali metal element from a glass substrate.

[0082] Next, a semiconductor film 103a having an amorphous structure is formed to a thickness of 25 to 80 nm (preferably 30 to 60 nm) by the widely known methods such as plasma CVD method and sputtering. For example, an amorphous silicon film is formed to a thickness of 55 nm by plasma CVD method. An amorphous semiconductor film and a fine crystalline semiconductor film are included in semiconductor films, and the compound semiconductor film having an amorphous structure such as an amorphous silicon germanium film etc. can be used. Besides, the both of the undercoating film 102 and the amorphous semiconductor film 103a can be formed continuously. For example, after the silicon oxide nitride film 102a and the silicon oxide nitride hydride film 102b are deposited continuously by plasma CVD method as mentioned above, if the reaction gas is switched over from SiH_4, N_2O and H_2 to SiH_4 and H_2, or only to SiH_4, these films can be formed is series without being exposed once in the atmosphere. As a result, the surface of the silicon oxide nitride hydride film 102b can be prevented from contamination, and the characteristic variation of TFT to be manufactured and the variation of threshold voltage can be reduced.

[0083] And then, a heat treating method by using a laser beam of the present invention (a laser crystallizing method is used here) is applied to crystallize the amorphous semiconductor film 103a. Any one of laser crystallizing methods explained in the embodiment modes 1 to 4 can be applied, concretely a method for crystallizing an amorphous semiconductor film shown in the embodiment modes 5 or 6 can be used. Because a substrate is heated locally and instantaneously by which a

linear pulse laser beam is irradiated, in case of using a glass substrate and a plastic one having inferior heat-resistance mentioned above, especially it is preferable that the laser crystallizing method of the present invention is applied.

[0084] A heat treating method by using a laser beam of the present invention is used suitably in a production method that a plurality of substrates for display device are cut from a kind of large-sized substrate shown in Figure 1. For example, in case that six substrates for display device of which screen size is 10.5 inch are cut from a substrate (mother glass) of 700 x 650 mm, it is preferable that the linear pulse laser beam is irradiated, of which length in the longitudinal direction (W shown in Figure 1) in the region to be irradiated is 300 nm. In this case, for example a linear laser beam can be irradiated, of which length in the longitudinal direction is 350 nm can be shortened to 300 nm by a slit as shown in Figure 1. If a slit is provided in an optical system of a laser apparatus so as to regulate the length in the longitudinal direction, a region to be irradiated with an arbitrary length can be formed corresponding to a screen size within the prescribed range.

[0085] The conditions of heat treating by using this laser beam are selected properly by a performer, for example, the laser pulse oscillating frequency is about 1kHz, and the laser energy density is 250 to 500 mJ/cm^2 (typically 300 to 400 mJ/cm^2). And then the linear beam is irradiated all over the surface of substrate, and the overlap rate (the overlap rate) of linear beam at this time is 80 to 99 % (preferably 95 to 99 %). In this way, the crystalline semiconductor film 103b can be obtained as shown in Figure 13 (B).

[0086] Next, a resist pattern is formed with a photo mask 1 (PM1) on the crystalline semiconductor film 103b by a technology of photolithography, and island-shaped semiconductor films 104 to 108 are formed by dividing the crystalline semiconductor film into an island-shape with dry etching as shown in Figure 13 (C). The mixed gas of CF_4 and O_2 is used for dry etching. Subsequently, a mask layer 194 of a silicon oxide film is formed to a thickness of 50 to 100 nm by plasma CVD method or sputtering.

[0087] To the island-shaped semiconductor film in this condition, the impurity element with concentration of about 1×10^{16} to 5×10^{17} $atoms/cm^3$ which grants p-type can be doped in all the surface of island-shaped semiconductor film for the purpose of controlling the threshold voltage (Vth) of TFT. As the impurity element for granting p-type to a semiconductor, elements of the

thirteenth group in the periodic law table such as boron (B), aluminum (Al), gallium (Ga), etc. are known. Though an ion implanting method and an ion doping method can be used for it, the ion doping method is suitable for treating a large-sized substrate. Boron (B) is doped by using diborane (B_2H_6) as a source gas in the ion doping method. Implantation of impurity element like this is not always necessary and can be omitted, however, especially it is used suitably for keeping the threshold voltage of n-channel type TFT within the prescribed range.

[0088] In order to form an LDD region of n-channel type TFT in a driving circuit, the impurity element for granting n-type is doped selectively into the island-shaped semiconductor films 105 and 107. Resist masks 195a to 195e are formed in advance. Phosphorus (P) and arsenic (As) can be used as the impurity element for granting n-type, accordingly the ion doping method with phosphine (PH_3) is applied here to dope phosphorus (P). The impurity regions are formed as n-type impurity regions 196 and 197 with low concentration, and it is preferable that the concentration of phosphorus (P) is within 2×10^{16} to 5×10^{19} atoms/cm^3. In the present specification, the concentration of impurity element for granting n-type which is contained in the impurity regions 196 and 197 formed here is expressed by (n^-). Besides, the impurity region 198 is a semiconductor film for forming a storage capacity of a pixel matrix circuit, to which phosphorus (P) with the same concentration is doped (Figure 13 (D).

[0089] Subsequently, a treating for activating the doped impurity element is performed. The treating for activation is performed by heat treating by using a laser beam explained in the embodiment mode 7. An example of heat treating conditions is that the laser pulse oscillating frequency is 1kHz and the laser energy density is 100 to 300 mJ/cm^2 (typically 150 to 250 mJ/cm^2). And then the linear beam is irradiated all over the surface of substrate, and the overlap rate (the overlap rate) of linear beam at this time is 80 to 99 % (preferably 95 to 99 %).

[0090] A gate insulating film 109 is an insulating film containing silicon which is formed to a thickness of 40 to 150 nm by plasma CVD method or sputtering. For example, it is preferable that it is made from a silicon oxide nitride film of 120 nm. Also, a silicon oxide nitride film formed by doping O_2 into SiH_4 and N_2O is a preferable material for this use because the fixed electric charge density in film is reduced. Of course, the gate insulating film is not limited to the silicon oxide nitride film like this, and single layer or lamination of insulating film containing other silicon can be

used (Figure 13 (E)).

[0091] Next, as shown in Figure 13 (E), a heat-resistant conductive layer for forming a gate electrode on the gate insulating film 109 is formed. The heat-resistant conductive layer can be formed by single layer, if necessary, the lamination structure comprising a plurality of layers such as two layers or three layers can be used. By using a heat-resistant conductive material like this, for example, the structure wherein a conductive layer (A) 110 made of a conductive nitride metal film and a conductive layer (B) 111 made of a metal film are laminated is preferable. The conductive layer (B) 111 can be formed by element selected from tantalum (Ta), titanium (Ti), molybdenum (Mo) and tungsten (W), an alloy of which main ingredient is said element, or an alloy film which is combined with said elements (typically Mo-W alloy film, Mo-Ta alloy film), and the conductive layer (A) 110 is formed by tantalum nitride (TaN), tungsten nitride (WN), titanium nitride (TiN) film, molybdenum nitride (MoN), etc. Also, tungsten silicide, titanium silicide, and molybdenum silicide can be applied to the conductive layer (A) 110. It is preferable that the impurity concentration contained in the conductive layer (B) 111 is reduced for reduction of resistance, especially, it is preferable that the oxygen concentration is not more than 30 ppm. For example, tungsten (W) can realizes the specific resistance which is not more than 20 $\mu\Omega$cm by which the oxygen concentration is made to be not more than 30 ppm.

[0092] The conductive layer (A) 110 can be 10 to 50 nm (preferably 20 to 30 nm), and the conductive layer (B) 111 can be 200 to 400 nm (preferably 250 to 350 nm). In case that W is used as a gate electrode, the conductive layer (A) 111 is formed with tungsten nitride (WN) to a thickness of 50 nm by introducing argon (Ar) gas and nitrogen (N_2) gas with sputtering method in which W is targeted, and the conductive layer (B) 110 is formed with W to a thickness of 250 nm. As the other method, a W film can be formed with tungsten fluoride (WF_6) by thermal CVD method. In either case, it is necessary to reduce the resistance for the purpose of using as the gate electrode, and it is preferable that the resistivity of the W film is not more than 20 $\mu\Omega$cm. The resistivity in the W film can be reduced by enlarging the grain boundaries, however, in case that a large number of impurity elements such as oxygen exist in the W film, crystallization is prevented so that the resistance is increased. Accordingly, in case of sputtering, by using W target of 99.999 % in purity, furthermore by forming the W film with enough consideration as the impurity from a gaseous

atmosphere is not mixed at deposition, the resistivity of 9 to 20 $\mu\ \Omega$cm can be realized.

[0093] On the other hand, in case that a TaN film is used for the conductive layer (A) 110, and a Ta film is used for the conductive layer (B) 111, they can be formed by sputtering in the same way. The TaN film is formed by using Ta as a target with the mixed gas of Ar and nitrogen for sputtering gas, and Ar is used for sputtering gas in the Ta film. Besides, when a proper quantity of Xe and Kr is added into these sputtering gases, the film can be prevented from peeling off by easing the inside stress of the film to be formed. The Ta film of α phase, of which resistivity is about 20 $\mu\ \Omega$cm, can be used for the gate electrode. However, the Ta film of β phase, of which resistivity is about 180 $\mu\ \Omega$cm, is not suitable for the gate electrode. Because the TaN film has the crystalline structure near to the α phase, the Ta film of α phase can be obtained easily if the Ta film is formed thereon. Besides, it is not shown in Figure, it is effective that a silicon film to which phosphorus (P) is doped is formed to a thickness of 2 to 20 nm under the conductive layer (A) 110. Consequently, a very small quantity of alkali metal element contained in the conductive layer (A) 110 or the conductive layer (B) 111 can be prevented from diffusing to the gate insulating film 109, as well as the improvement of the adhesive properties and the prevention of oxidization of the conductive film formed thereon are designed. In either case, it is preferable that the resistivity of the conductive layer (B) 111 is within 10 to 50 $\mu\ \Omega$cm.

[0094] Next, resist masks 112 to 117 are formed by using the technology of photolithography with a photo mask 2 (PM2), and gate electrodes 118 to 122 and a capacity wiring 123 are formed by etching the conductive layer (A) 110 and the conductive layer (B) 111 together. The gate electrodes 118 to 122 and the capacity wiring 123 are formed integrally by 118a to 112a made of the conductive layer (A) and 118b to 122b made of the conductive layer (B) (Figure 14 (A)).

[0095] A method for etching the conductive layer (A) and the conductive layer (B) can be selected suitably by performers, however when they are formed by materials of which main ingredients are W mentioned above, it is desirable that a dry etching method by using plasma with high density is applied in order to etch with high-speed and accuracy. As one method for obtaining plasma with high density, it is preferable to use an inductively coupled plasma (ICP) etching apparatus. The etching method of W by using ICP etching apparatus is that two kinds of gases of CF_4 and Cl_2 as etching gases are introduced to a reaction chamber, the pressure is 0.5 to 1.5 Pa (preferably 1 Pa),

and the electricity with high frequency of 200 to 1000 W (13.56 MHz) is applied to the inductively coupled portion. At this time, a stage on which a substrate is set is applied with the electricity with high frequency of 20 W, it becomes negatively charged by self-bias, consequently the anisotropic etching can be performed by which plus ions are accelerated. By using the ICP etching apparatus, the etching rate of 2 to 5 nm/sec can be obtained in a hard metal film such as W etc. Besides, in order to etching without the rest, it is preferable that over etching is performed by increasing the etching time in a ratio of about 10 to 20 %. However, it is necessary to pay attention to the selective ratio of etching with the undercoating. For example, because the selective ratio of the silicon oxide nitride film (the gate insulating film 109) to the W film is 2.5 to 3, the exposed face of the silicon oxide nitride film is etched about 20 to 50 nm by such over-etching treating, consequently it becomes thin substantially.

[0096] And then, in order to form an LDD region in an n-channel type TFT of a pixel TFT, a process of doping impurity element for granting n-type (n^- doping process) is performed. The impurity element for granting n-type in a self-alignment manner is doped by the ion doping method by using the gate electrodes 118 to 122 as masks. The concentration of phosphorus (P) which is doped as the impurity element for granting n-type is in a range of 10×10^{16} to 5×10^{19} atoms/cm^3. In this way, n-type impurity regions with low concentration 124 to129 are formed on the island-shaped semiconductor film as shown in Figure 14 (B).

[0097] Next, to the n-channel type TFT, an n-type impurity region with high concentration which functions as a source region or a drain region is formed (n^+ doping process). First, resist masks 130 to 134 are formed with a photo mask 3 (PM3), and the n-type impurity regions with high concentration 135 to 140 are formed by doping impurity element for granting n-type. Phosphorus (P) is used as the impurity element for granting n-type, the ion doping method by using phosphine (PH_3) is performed as the concentration is within a range of 1×10^{20} to 1×10^{21} atoms/cm^3 (Figure 14(C)).

[0098] And then, p-type impurity regions with high concentration 144 and 145 as the source region and the drain region are formed on island-shaped semiconductor films 104 and 106 for forming a p-channel type TFT. The p-type impurity region with high concentration is formed in a self-alignment manner by doping the impurity element for granting p-type with gate electrodes 118

and 120 used as masks here. At this time, island-shaped semiconductor films 105, 107 and 108 for forming n-channel type TFT are covered overall with resist masks 141 to 143 which are formed with a photo mask 4 (PM4). The p-type impurity regions with high concentration 144 and 145 are formed by the ion doping method by using diborane (B_2H_6). The concentration of boron (B) in this region is made to be 3 x 10^{20} to 3 x 10^{21} atoms/cm^3 (Figure 14 (D)).

[0099] Phosphorus (P) is doped in these p-type impurity regions with high concentration 144 and 145 in the previous process, so that it is contained with the concentration of 1 x 10^{20} to 1 x 10^{21} atoms/cm^3 in the p-type impurity regions with high concentration 144a and 145a, and it is contained with the concentration of 1 x 10^{16} to 5 x 10^{19} atoms/cm^3 in the p-type impurity regions with high concentration 144b and 145b. If the concentration of boron (B) doped in this process is increased by one-and-a half to three, any problem is not caused on the function as the source region and the drain region of p-channel type TFT.

[0100] Subsequently, as shown in Figure 15 (A), a protective insulating film 146 is formed on the gate electrode and the gate insulating film. The protective insulating film can be formed with a silicon oxide film, a silicon oxide nitride film, a silicon nitride film or a lamination layer of combination of these ones. In either case, the protective insulating film 146 is made from an inorganic insulating material. A thickness of the protective insulating film 146 is 100 to 200 nm. When the silicon oxide film is used here, it is formed with plasma CVD method by mixing TEOS (Tetraethyl Orthosilicate) and O_2, and by discharging under the reaction pressure of 40 Pa, the substrate temperature of 300 to 400 ℃, the high frequency (13.56 MHz), the electric density of 0.5 to 0.8 W/cm^2. When the silicon oxide nitride film is used, it can be formed with a silicon oxide nitride film made from SiH_4, N_2O and NH_3, or a silicon oxide nitride film made from SiH_4 and N_2O by plasma CVD method. The manufacturing conditions in this case are the reaction pressure of 20 to 200 Pa, and the substrate temperature of 300 to 400 ℃, and the high frequency (60MHz) electric density of 0.1 to 1.0 W/cm^2. Also, a silicon oxide nitride hydride film made from SiH_4, N_2O and H_2 can be used. A silicon nitride film can be formed from SiH_4 and NH_3 by plasma CVD method in the same way.

[0101] Subsequently, a process for activating the impurity elements for granting n-type or p-type which are doped with respective concentrations is performed. This process can be performed by

thermal annealing by using a furnace for furnace annealing, besides it can be activated by heat treating method by using a laser beam explained in the embodiment mode 7. The condition of heat treating in this case is the same as that one mentioned above. On the other hand, in case of thermal annealing, the concentration of oxygen is not more than 1 ppm, preferably not more than 0.1 ppm in a nitrogen atmosphere at 400 to 700 ℃, typically at 500 to 600 ℃, accordingly the heat treating is performed at 550 ℃ for four hours in the present embodiment. Besides, when a plastic substrate with low heat-resistant temperature is used as the substrate 101, it is preferable to use the heat treating method by using a laser beam of the present invention (Figure 15 (B)).

[0102] After heat treating, furthermore, a heat treating is performed in a hydrogen atmosphere from 3 to 100 %, at 300 to 450 ℃, for one to twelve hours, and a process for hydrogenating an island-shaped semiconductor film is performed. This process is for ending a dangling bond of 10^{16} to $10^{18}/cm^3$ in the island-shaped semiconductor film by hydrogen excited thermally. As the other means of hydrogenation, plasma hydrogenation (use hydrogen excited by plasma) can be performed.

[0103] When the combination of a heat treating method by using a laser beam of the present invention and a plasma hydrogenation treating is performed, an apparatus having structure shown in Figure 3 can be used. Concretely, the heat treating by using a laser beam is performed in a treating chamber 818, subsequently the substrate is transferred to a treating chamber 816 by a transferring means 820 and treating of plasma hydrogenation is performed. If hydrogen gas, ammonia gas etc. is introduced into the treating chamber 816, plasma hydrogenation can be performed easily. In this way, by storing substrates in the apparatus and treating in series without being exposed to the air, the contamination on the surface of the substrate can be prevented, besides, throughput can be improved.

[0104] And then, an interlayer insulating film 147 made from an organic insulating material is formed to an average thickness of 1.0 to 2.0 μm. As the organic resin material, polyimide, acryl, polyamide, polyimideamide, BCB (benzocyclobutene), etc. can be used. For example, when polyimide which is polymerized thermally after coating on the substrate is used, it is formed by baking at 300 ℃ in a clean oven. Besides, in case of using acryl, two liquid of the main material and hardening are mixed, which is applied to all the surface of substrate by a spinner, subsequently

the preparatory heating is performed at 80 ℃ for 60 seconds on a hot plate, and then baking is performed at 250 ℃ for 60 minutes in a clean oven, consequently the film can be formed.

[0105] In this way, the interlayer insulating film is formed with the organic insulating material so that the surface can be planarized satisfactorily. Besides, because the organic resin material has low dielectric rate generally, a parasitic capacity can be reduced. However, it is hygroscopic so that it is not suitable for a protective film, consequently as the present embodiment, it is necessary to use by combining with a silicon oxide film, a silicon oxide nitride film, a silicon nitride film, etc. formed as the protective insulating film 146.

[0106] Subsequently, a resist mask with the prescribed pattern is formed by using a photo mask 5 (PM5), and contact holes which reach the source regions or the drain regions formed on the respective island-shaped semiconductor films. The contact holes are formed by dry etching method. In this case, the interlayer insulating film made from the organic resin material is first etched by using the mixed gas of CF_4, O_2, He as the etching gas, subsequently the protective insulating film 146 is etched by using CF_4 and O_2 as etching gas successively. Furthermore, in order to increase the selection ratio with the island-shaped semiconductor film, the gate insulating film is etched by changing the etching gas into CHF_3, consequently the contact holes can be formed satisfactorily.

[0107] And then, a conductive metal film is formed by sputtering and vacuum evaporation, a resist mask pattern is formed with a photo mask 6 (PM6), and source wirings 148 to 152 and drain wirings 153 to 157 are formed by etching. The drain wiring 157 functions as a pixel electrode here. It is not shown in figure, in the present embodiment, this electrode is formed with a Ti film to a thickness of 50 to 150 nm, a semiconductor film for forming a source or a drain region of the island-shaped semiconductor film and a contact are formed, and wiring is made by forming aluminum (Al) to a thickness of 300 to 400 nm piled up on the Ti film.

[0108] When hydrogenation treating is performed in this condition, the preferable result can be obtained for improvement of TFT characteristic. For example, it is preferable that heat treating is performed in an atmosphere containing hydrogen of 3 to 100 % at 300 to 450 ℃ for 1 to 12 hours, or if plasma hydrogenation method is used, the same effect can be obtained. Also, hydrogenation can be performed by diffusing hydrogen which exists in the protective insulating film 146 and the

undercoating film 102 to the island-shaped semiconductor films 104 to 108 by heat treating like this. In either case, it is desirable that the defect density in the island-shaped semiconductor films 104 to 108 is not more than $10^{16}/cm^3$, accordingly it is preferable that hydrogen of about 0.01 to 0.1 atomic% is granted (Figure 15 (C)).

[0109] A substrate having TFT of a driving circuit and a pixel TFT of a pixel portion on the same substrate can be accomplished by seven photo masks in this way. A first p-channel type TFT 200, a first n-channel type TFT 201, a second p-channel type TFT 202, a second n-channel type TFT 203 are formed in the driving circuit, and a pixel TFT 204 and a storage capacity 205 are formed in the pixel portion. A substrate like this is referred to as an active matrix substrate for convenience in the present specification.

[0110] The first p-channel type TFT 200 of the driving circuit has a single drain structure comprising a channel forming region 206, source regions 207a and 207b, and drain regions 208a and 208b made of a p-type impurity region with high concentration on the island-shaped semiconductor film 104. The first n-channel type TFT 201 has a channel forming region 209, an LDD region 210 overlapped with the gate electrode 119, a source region 212 and a drain region 211 on the island-shaped semiconductor film 105. In this LDD region, when the LDD region overlapped with the gate electrode 119 is Lov, the length in the channel length direction is 0.5 to 3.0 μm, preferably 1.0 to 2.0 μm. By changing the length of the LDD region in the n-channel type TFT in this way, the high electric field generated in adjacency of the drain region is eased, hot carrier is prevented form generating, and TFT can be prevented from deteriorating. The second p-channel type TFT 202 of the driving circuit has the same single drain structure comprising a channel forming region 213, source regions 214a and 214b, and drain regions 215a and 215b made of a p-type impurity region with high concentration on the island-shaped semiconductor film 106. In the second n-channel type TFT 203, a channel forming region 216, an LDD regions 217 and 218 of which one portion is overlapped with the gate electrode 121, a source region 220 and a drain region 219 are formed on the island-shaped semiconductor film 107. The length of Lov overlapped with the gate electrode of this TFT is 0.5 to 3.0 μm, preferably 1.0 to 2.0 μm. Besides, when the LDD region which is not overlapped with the gate electrode is Loff, the length in this channel length direction is 0.5 to 4.0 μm, preferably 1.0 to 2.0 μm. The pixel TFT 204 has

a channel forming regions 221 and 222, LDD regions 223 to 225, source or drain regions 226 to 228 on the island-shaped semiconductor film 108. The length in the channel length direction of the LDD region (Loff) is 0.5 to 4.0 μm, preferably 1.5 to 2.5 μm. Furthermore, the storage capacity 205 is formed by a capacity wiring 123, an insulating film made from the same materials as the gate insulating film, and a semiconductor film 229 connected to the drain region 228 of the pixel TFT 204. The pixel TFT 204 has a double gate structure in Figure 15 (C), however, a single gate structure, or a multi-gate structure wherein a plurality of gate electrodes are provided can be used.

[0111] Figure 25 is an upper side view showing about one pixel of a pixel portion. A cross section of A-A' shown in figure corresponds to a cross sectional view of a pixel portion shown in Figure 15 (C). A gate electrode 122 of the pixel TFT 204 is crossed with the island-shaped semiconductor film 108 there under through the gate insulating film which is not shown in Figure. Besides, the gate electrode 122 is in contact with a gate wiring 900 made of low resistant conductive material formed by using a material of Al, Cu, etc. outside of the island-shaped semiconductor film 108 without through a contact hole. A source region, a drain region, and an LDD region are formed on the island-shaped semiconductor film 108, which are not shown in Figure. Besides, 256 shows a contact portion with the source wiring 152 and the source region 226, and 257 shows a contact portion with the drain wiring 157 and the drain region 228. The storage capacity 205 is formed with a region where the semiconductor film 229 extending from the drain region 228 of the pixel TFT 204 is overlapped with the capacity wiring 123 through the gate insulating film. The impurity element for controlling valence electron is not doped to the semiconductor film 229 in this constitution.

[0112] Due to the constitution mentioned above, the structure of TFT which constitutes each circuit corresponding to the way requested by the pixel TFT and the driving circuit is made to be suitable, and operation performance and reliability of the semiconductor device can be improved. Furthermore, the LDD region, the source region and the drain region are activated easily by forming the gate electrode with a conductive material having heat-resistance. For manufacturing an active matrix substrate wherein such TFT is provided, if a heat treating method by using a laser beam of the present invention and a laser apparatus are used, TFT with fine characteristics can be

manufactured, and the productivity can be improved. A liquid crystal display device and an EL display device can be manufactured by using such active matrix substrate.

[0113] [Embodiment 2] An example of using a conductive material with heat-resistance such as W, Ta, etc. as a material for a gate electrode of TFT is shown in the embodiment 1. The reason why such material is used is caused by a plurality of factors of activating the impurity element mainly which is doped to a semiconductor film for the purpose of controlling valence electron after forming the gate electrode by thermal annealing at 400 to 700℃, preventing electromigration, improving corrosion-resistance, etc. However, the conductive material with heat-resistance like this has an area resistance of about 10 Ω, so that it is not suitable for the liquid crystal display device and the EL display device of which screen size is 4 inch or more. Because the gate wiring connected to the gate electrode is formed with the same material so that leading length on the substrate becomes long necessarily, consequently the delay time owing to the wiring resistance cannot be ignored.

[0114] For example, 480 gate wirings and 640 source ones are formed when the pixel density is VGA, and 768 gate wirings and 1024 source ones are formed when the pixel density is XGA. Concerning the screen side of display region, the length of a diagonal line is 340 mm in case of 13 inch class, and it is 460 mm in case of 18 inch class. A method for forming the gate wiring with a low resistant conductive material such as Al, copper (Cu), etc. is explained with Figure 16, as a means for realizing a liquid crystal display device like this in the present embodiment.

[0115] First, processes shown in Figure 13 (A) to Figure 14 (D) are performed in the same way as the embodiment 1. And then, a treating for activating the impurity elements which are doped into respective island-shaped semiconductor films is performed for the purpose of controlling valence electrons. It is the most preferable that this treating for activation is performed by a heat treating method by using a laser beam shown in the embodiment mode 7. Furthermore, the island-shaped semiconductor film is hydrogenated by which a heat treating is performed in an atmosphere of hydrogen of 3 to 100 %, at 300 to 450 ℃, for 1 to 12 hours. This process is for ending dangling bond of the semiconductor film by thermally excited hydrogen. As the other means for hydrogenation, plasma hydrogenation (using hydrogen excited by plasma) can be performed (Figure 16 (A)).

[0116] After treatings of activation and hydrogenation, the gate wiring is formed with a low resistant

conductive material. This low resistant conductive layer is formed with a conductive layer (D) of which main ingredient is Al and Cu. For example, an Al film containing Ti of 0.1 to 2 wt% is formed overall as the conductive layer (D) (it is not shown in Figure). It is preferable that the conductive layer (D) 145 is 200 to 400 nm (preferably 250 to 350 nm). And then, the prescribed resist pattern is formed with a photo mask, and etching is performed, so that gate wirings 163 and 164 and a capacity wiring 165 are formed. The gate wiring can be formed by etching treating by which the conductive layer (D) is removed by wet etching with etching solution of phosphoric acid series as the selective processability with undercoating is kept. Consequently a protective insulating film 146 is formed (Figure 16 (B)).

[0117] Subsequently, an active matrix substrate can be accomplished by forming an interlayer insulating film 147 made from an organic insulating material, source wirings 148 to 151 and 167, and drain wirings 153 to 156 and 168 in the same way as the embodiment 1. Figure 17 (A) and (B) are upper side views in this condition, and a cross section of B-B' of Figure 17 (A) and that of C-C' of Figure 17 (B) correspond to those of A-A' and C-C' of Figure 16 (C). The gate insulating film, the protective insulating film and the interlayer insulating film are omitted in Figure 17 (A) and (B), however, the source wirings 148, 149 and 167 and the drain wirings 153, 154 and 168 are connected through contact holes to source and drain regions, which are not shown in figure, of the island-shaped semiconductor films 104, 105 and 108. Besides, a cross section of D-D' of Figure 17 (A) and that of E-E' of Figure 17 (B) are shown in Figure 18 (A) and (B) respectively. The gate wiring 163 is formed so as to overlap with the gate electrodes 118 and 119, and the gate wiring 164 is formed so as to overlap with the gate electrode 122 outside, the island-shaped semiconductor films 104, 105 and 108, accordingly the conductive layer (C) is in contact with (D) and they are conducted electrically. The wiring resistance can be reduced sufficiently by forming the gate wiring with low resistant conductive material in this way. Therefore, it can be applied to a liquid crystal display device and an EL display device of which pixel portion (screen size) is not less than 4 inch class.

[0118] [Embodiment 3] An active matrix substrate manufactured in the embodiment 1 can be applied to a reflective type liquid crystal display device as it is. On the other hand, in case of transmissive type liquid crystal display device, a pixel electrode provided in each pixel of a pixel

portion can be formed with a transparent electrode. A method for manufacturing an active matrix substrate corresponding to a transmissive type liquid crystal display device is explained with Figure 10 in the present embodiment.

[0119] An active matrix substrate is manufactured in the same way as the embodiment 1. In Figure 20 (A), a source wiring and a drain wiring are formed with a conductive metal film by sputtering and vacuum evaporation. A Ti film is formed to a thickness of 50 to 150 nm, a semiconductor film for forming a source or drain region of an island-shaped semiconductor film and a contact are formed, aluminum (Al) is formed to a thickness of 300 to 400 nm in piles on the Ti film, furthermore, a Ti film or a titanium nitride (TiN) film is formed to a thickness of 100 to 200 nm, consequently a three-layered structure is made. Subsequently, a transparent conductive film is formed overall, and a pixel electrode 171 is formed by patterning treating and etching treating with a photo mask. The pixel electrode 171 is formed on an interlayer insulating film 147, and a connection structure is formed by providing a portion overlapped with the drain wiring 169 of the pixel TFT 204.

[0120] Figure 20 (B) shows an example that a transparent conductive film is formed on an interlayer insulating film 147 first, and after a pixel electrode 171 is formed by patterning treating and etching treating, a drain wiring 169 is formed by providing a portion overlapped with the pixel electrode 171. The drain wiring 169 is provided by forming a Ti film to a thickness of 50 to 150 nm, forming a semiconductor film for forming source or drain region of an island-shaped semiconductor film and a contact, and forming aluminum (Al) to a thickness of 300 to 400 nm in piles on the Ti film. If it is constituted in this way, the pixel electrode 171 is in contact with only Ti film which forms the drain wiring 169. As a result, a material for transparent conductive film can be prevented from reacting on Al.

[0121] As the material of transparent conductive film, indium oxide (In_2O_3), an alloy of indium oxide tin oxide (In_2O_3-SnO_2; ITO), etc. can be formed with sputtering and vacuum evaporation and be used. An etching treating of such materials is performed with a solution of hydrochloric acid series. However, especially because an unetched portion is easy to produce in etching of ITO, an alloy of indium oxide zinc oxide (In_2O_3-ZnO) can be used to improve the etching processability. The alloy of indium oxide zinc oxide is excellent in the evenness of surface, and also in the stability

to heat to ITO, so that the corrosion reaction with Al which is in contact with the edge side of the drain wiring 169 can be prevented. Equally, zinc oxide (ZnO) is also suitable material, furthermore zinc oxide etc. into which gallium (Ga) is doped (ZnO:Ga) can be used in order to improve transmittance and conductivity of visible rays.

[0122] In this way, an active matrix substrate corresponding to a transmissive liquid crystal display device can be accomplished. In the present embodiment, the constitution like this is explained as the same process as the embodiment 1, which can be applied to an active matrix substrate shown in the embodiments 2 and 3.

[0123] [Embodiment 4] As shown in the embodiment mode 6, a method by which a crystalline semiconductor film is obtained by using a catalytic element promoting crystallization of an amorphous semiconductor film, furthermore the crystallization rate is improved by a heat treating method by using a linear laser beam of the present invention (laser crystallizing method) is effective for the purpose of manufacturing TFT with high field effect mobility. However, in this case, a very small quantity (about 1×10^{17} to 1×10^{19} atoms/cm^3) of catalytic elements are left in the crystalline semiconductor film. Of course, TFT can be accomplished in such a condition, however, it is more preferable that the catalytic element which is left is removed from at least channel forming region in order to lower the OFF current. One of the means for removing this catalytic element is making use of gettering action by phosphorus (P).

[0124] The gettering treating by phosphorus (P) in this purpose can be performed simultaneously in the activating process explained in Figure 15 (B). This situation is explained with Figure 19. The concentration of phosphorus (P) necessary for gettering can be the same as that of impurity in n-type impurity region with high concentration, and by thermal annealing of the activating process, the catalytic elements can be segregated with its concentration kept from the channel forming region of n-channel type TFT and p-channel type TFT to the impurity region containing phosphorus (P) (the direction of arrow shown in Figure 19). As a result, the catalytic elements of about 1×10^{17} to 1×10^{19} atoms/cm^3 are segregated in the impurity region. The TFT manufactured in this way can obtain high field effect mobility because the OFF current value is lowered and the crystallinity is fine, and achieve excellent characteristics.

[0125] [Embodiment 5] A process for manufacturing an active matrix type liquid crystal display

device from an active matrix substrate manufactured in the embodiment 1 is explained in the present embodiment. First, as shown in Figure 21 (A), a spacer composed of a pillar-shaped spacer is formed on an active matrix substrate in the condition of Figure 15 (C). The spacer can be provided by spraying particles of several μ m, however, it is formed here by which a resin film is formed in all the surface of substrate, subsequently it is patterned. The material of spacer like this is not limited, for example, NN700 of JSR is used, which is applied with spinner, subsequently the prescribed pattern is formed by exposing and developing treating. Furthermore, it is hardened by being heated at 150 to 200 ℃ in a clean oven etc. The spacer manufactured in this way of which shape can be made to vary by the conditions of exposing and developing treating, preferably, if the pillar-shaped spacer 173 is a pillar-shape and of which top portion is flat, the mechanical strength as a liquid crystal display panel can be secured when a substrate on the opposite side is put together. The shape is not limited specially such as a conic shape, a pyramid shape, etc., for example in case of conic shape, concretely the height is 1.2 to 5 μ m, the average radius is 5 to 7 μ m, and the ratio of the average radius to the radius of the bottom portion is about 1 to 1.5. At this time, it is preferable that the taper angle seen from the cross section is not more than ± 15℃.

[0126] The arrangement of pillar-shaped spacers can be decided arbitrarily, preferably, as shown in Figure 21 (A), the pillar-shaped spacer 168 is formed so as to cover the portion by piling a contact portion 235 of a drain wiring 161 (pixel electrode) in a pixel portion. The contact portion 235 is damaged in evenness so that liquid crystal is not orientated well in this portion, accordingly disclination etc. can be prevented by which the pillar-shaped spacer 168 is formed by filling resin for spacer into the contact portion 235 in this way.

[0127] Subsequently, an alignment film 174 is formed. Generally polyimide resin is used for the alignment film of liquid crystal display element. After forming the alignment film, rubbing treating is performed so that liquid crystal molecular aligns with some regular pre-tilt angle. The region which is not rubbed from the edge portion of the pillar-shaped spacer 173 provided in the pixel portion to the rubbing direction is made to be not more than 2 μ m. Besides, it often becomes a problem that static electricity is generated in rubbing treating, and if the spacer 172 is formed on TFT of the driving circuit, the original role as a spacer and the effect of protecting TFT from the static electricity can be obtained.

[0128] A shielding film 176, a transparent conductive film 177 and an alignment film 178 are formed on a counter substrate 175 on the opposed side. The shielding film 176 is formed with Ti, Cr, Al, etc. to a thickness of 150 to 300 nm. And then, the active matrix substrate on which the pixel portion and the driving circuit are formed and the counter substrate are stuck together with a sealing agent 179. A filler 180 is mixed in the sealing agent 179, so that two substrates can be stuck together with an uniform interval by this filler 180 and the spacers 172 and 173. Subsequently, a liquid crystal material 606 is poured between both substrates, which are sealed completely with sealing agent (not shown in Figure). The widely known liquid crystal material can be used. Consequently, the active matrix type liquid crystal display device shown in Figure 21 (B) is accomplished.

[0129] An example of forming the spacer 172 in all the surface of TFT of the driving circuit is shown in Figure 21, however, this spacer is divided into plurality and can be formed as spacers 172a to 172e as shown in Figure 22. It is preferable that the spacer provided on the portion where a driving circuit is formed is formed so as to cover at least a source wiring and a drain wiring of the driving circuit in this way. Because of such constitution, each TFT of the driving circuit can be covered and protected completely with the protective insulating film 146, the interlayer insulating film 147, and the spacer 172 or the spacers 172a to 172e.

[0130] Figure 23 is an upper side view of an active matrix substrate wherein a spacer and a sealing agent are formed, which shows the relation of position among a pixel portion and a driving circuit portion, and a spacer and a sealing agent. A scanning signal driving circuit 185 and a image signal driving circuit 186 are provided as driving circuits around a pixel portion 188. Furthermore, a signal processing circuit 187 of CPU, memory, etc. can be added. And then, these driving circuits are connected to an external input and output terminal 182 by a connection wiring 183. In the pixel portion 188, a pixel is formed by which a group of gate wirings 189 extended from the scanning signal driving circuit 185 and a group of source wirings 190 extended from the image signal driving circuit 186 are crossed in matrix shape, and a pixel TFT 204 and a storage capacity 205 are provided respectively in each pixel.

[0131] The spacer 173 provided in the pixel portion can be provided on all the pixels, and also can be provided at intervals of several to several tens pixels arranged in matrix shape. That is to say, it

is preferable that the ratio of the number of spacer to all the number of pixels constituting the pixel portion is 20 to 100 %. Besides, the spacers 172, 172' and 172" provided in the driving circuit portion can be provided so as to cover all the surface, or can be provided by dividing into plurality aligning to the position of the source and the drain wiring of each TFT as shown in Figure 22. The sealing agent 179 is formed outside the pixel portion 188, the scanning signal controlling circuit 185, the image signal controlling circuit 186, and other signal processing circuit 187, and inside the external input and output terminal 182 on the substrate 101.

[0132] A constitution of an active matrix type liquid crystal display device like this is explained with an oblique view of Figure 24. In Figure 24, the active matrix substrate is constituted by the pixel portion 188, the scanning signal driving circuit 185, the image signal driving circuit 186 and other signal processing circuit 187 which are formed on the glass substrate 101. The pixel TFT 204 and the storage capacity 205 are provided in the pixel portion 188, and the driving circuit provided around the pixel portion is constituted by CMOS circuit as a base. The scanning signal driving circuit 185 and the image signal driving circuit 186 are connected respectively to the pixel TFT 204 with the gate wiring 122 and the source wiring 152. Besides, a flexible printed circuit (FPC) 191 is connected to the external input terminal 182, which is used for inputting an image signal etc. And it is connected to respective driving circuits with the connection wiring 183. A shielding film and a transparent electrode, which are not shown in Figure, are provided on the counter substrate 175.

[0133] The liquid crystal display device having such constitution can be formed by using the active matrix substrate shown in the embodiments 1 to 4. If the active matrix substrate shown in the embodiments 1 to 3 is used, the reflecting type liquid crystal display device can be obtained, and if the active matrix substrate shown in the embodiment 4, the transmissive type one can be obtained.

[0134] [Embodiment 6] In the present embodiment, an example of manufacturing a self-emitting type display panel with an electroluminescence (EL: Electro Luminescence) material (hereinafter referred to as EL display device) by using the active matrix substrate of the embodiment 5 is explained. Figure 26 (A) is an upper side view of an EL display panel by using the present invention. In Figure 26 (A), 10 is a substrate, 11 is a pixel portion, 12 is a source side driving circuit, 13 is a gate side driving circuit, and respective driving circuits lead to FPC 17 through

wirings 14 to 16 and are connected to an external apparatus.

[0135] Figure 26 (B) is a cross sectional view of A-A' of Figure 26 (A), and a counter plate 80 is provided at least on a pixel portion, preferably on a driving circuit and the pixel portion at this time. The counter plate 80 is stuck together by a sealing material 19 with an active matrix substrate wherein a TFT and a self-emitting layer made with an EL material are formed. Filler (not shown in Figure) is mixed into the sealing material 19, and two substrates are stuck together at about regular intervals by this filler. Furthermore, constitutionally the outside of sealing material 19 and the upper face and the periphery of FPC 17 are sealed by sealing agent 81. Silicon resin, epoxy resin, phenolic resin, butyl rubber, etc. are used for the sealing agent 81.

[0136] In this way, the active matrix substrate 10 and the counter substrate 80 are stuck together by the sealing material 19, accordingly a space is formed between them. A filler 83 is poured between the space. This filler 83 also has the effect of adhering the counter plate 80. PVC (polyvinylchloride), epoxy resin, silicon resin, PVB (polyvinylbutyral), EVA (ethylenevinylacetate), etc. can be used for the filler 83. Besides, the self-emitting layer is easily affected by moisture and humidity so that it is easily deteriorated, accordingly it is desirable that a desiccant such as barium oxide is mixed to the inside of this filler 83 to keep the moisture absorption effect. Furthermore, constitutionally the corrosion by alkali element etc. contained in the filler 83 is prevented by forming a passivation film 82 made with a silicon nitride film, a silicon oxide nitride film, etc. on the self-emitting layer.

[0137] For the counter plate 80, a glass plate, an aluminum plate, a stainless plate, FRP (Fiberglass-Reinforced Plastics) plate, PVF (polyvinylfluoride) film, mylar film (a brand name of Dupon), a polyester film, an acrylic film or plate, etc. can be used. Also, the moisture-resistance can be improved by using a sheet having structure that an aluminum foil of several tens μm is interposed with PVF film and mylar film. In this way, the EL element is made airtight and is shut off from the air.

[0138] Besides, a TFT for driving circuit (however, CMOS circuit combining an n-channel type TFT and a p-channel type TFT are shown in Figure.) 22 and a TFT for pixel portion 23 (however, only TFT for controlling current to the EL element is shown in Figure.) are formed on the substrate 10 and the undercoating film 21 in Figure 26 (B). An LDD region having the constitution shown

by the present embodiment mode is provided especially in the n-channel type TFT among these TFTs, in order to prevent the ON current from reducing by the hot carrier effect, and the characteristics from reducing by Vth shift and bias stress.

[0139] For example, p-channel type TFTs 200 and 202, and n-channel type TFTs 201 and 203 shown in Figure 15 (C) can be used for the TFT for driving circuit 22. Also, a pixel TFT 204 shown in Figure 15 (B) or a p-channel type TFT having the same structure as 204 can be used for a TFT for pixel portion 23.

[0140] In order to manufacture the EL display device from the active matrix substrate in the condition of Figure 15 (C) or Figure 16 (C), an interlayer insulating film (a planarizing film) 26 made from resin material is formed on the source wiring and the drain wiring, on which a pixel electrode 27 made with a transparent conductive film connected to a drain of TFT 23 for pixel portion electrically is formed. The compound of indium oxide and tin oxide (referred to as ITO) or that of indium oxide and zinc oxide can be used for the transparent conductive film. After the pixel electrode 27 is formed, the insulating film 28 is formed, subsequently an aperture is formed on the pixel electrode 27.

[0141] Next, a self-emitting layer 29 is formed. The self-emitting layer 29 can be a lamination structure or a single structure by combining the widely known EL materials (a hole implanting layer, a hole transferring layer, a light emitting layer, an electron transferring layer or an electron implanting layer) freely. The widely known technology can be used in what kind of structure is used. Besides, monomer series materials and polymer series materials are included in the EL materials. The evaporation method is used when the monomer series materials are used, and easy methods such as the spin coat method, the printing method, the ink jet method, etc. can be used when the polymer series materials are used.

[0142] The self-emitting layer is formed with a shadow mask by the evaporation method, the ink jet method, the dispenser method, etc. In either case, displaying with colors can be performed by forming light emitting layers (red color emitting layer, green color emitting layer and blue color emitting layer) wherein light emission with different wavelength is possible per pixel. In addition to it, any one of methods of combining a color conversion layer (CCM) and color filters, and a method of combining a white color emitting layer and color filters, can be used. Of course, the EL

display device of single color emission is possible.

[0143] After the self-emission layer 29 is formed, a cathode 30 is formed thereon. It is desirable that moisture and oxygen which exist on the interface between the cathode 30 and the self-emitting layer 29 are removed to the utmost. Therefore, means that the self-emission layer 29 and the cathode 30 are formed successively in a vacuum, or the self-emission layer 29 is formed in an inert gas atmosphere and the cathode 30 is formed in a vacuum without releasing into the air are necessary. The deposition mentioned above is possible by using a deposition apparatus of multi-chamber system (cluster tool system) in the present invention.

[0144] Besides, the lamination structure of a LiF (lithium fluoride) film and an Al (aluminum) film is used for the cathode 30 in the present embodiment. Concretely the LiF (lithium fluoride) film is formed to a thickness of 1 nm on the self-emission layer 29 by evaporation, on which the aluminum film is formed to a thickness of 300 nm. Of course, MgAg electrode of the widely known cathode material can be used. And then, the cathode 30 is connected to a wiring 16 in the region shown by 31. The wiring 16 is a power supply line for supplying the prescribed voltage to the cathode 30, and is connected to FPC 17 through an anisotropic conductive paste material 32. A resin layer 80 is formed furthermore on the FPC 17 so that the bond strength of this portion is increased.

[0145] In order to connect the cathode 30 to the wiring 16 electrically in the region shown by 31, it is necessary to form contact holes in the interlayer insulating film 26 and the insulating layer 28. These holes can be formed when the interlayer insulating film 26 is etched (at forming the contact hole for the pixel electrode) and when the insulating film 28 is etched (at forming the aperture before forming the self-emission layer). Besides, when the insulating film 28 is etched, the interlayer insulating film 26 can be etched together. In this case, if the interlayer insulating film 26 and the insulating film 28 are made from the same resin material, the shape of contact hole can be fine.

[0146] Also, the wiring 16 is connected to FPC 17 electrically through the clearance (however it is filled with the sealing agent 81) between sealing agent 19 and the substrate 10. Besides, the wiring 16 is explained here, and other wirings 14 and 15 are connected to FPC 17 electrically passing through under the sealing material 18 in the same way.

[0147] The furthermore detailed structure of cross section in a pixel portion is shown in Figure 27,

the upper side structure is shown in Figure 28 (A), and a circuit diagram is shown in Figure 28 (B). In Figure 27 (A), TFT 2402 for switching provided on a substrate 2401 is formed with the same structure as a pixel TFT 204 in Figure 15 (C) of the embodiment 1. Two TFTs are connected in series substantially by double gate structure, accordingly advantage is brought that the OFF current value can be reduced. Also, the double gate structure is used in the present embodiment, a triple gate structure and a multi gate structure having more gates can be used.

[0148] Besides, TFT 2403 for controlling current is formed with the n-channel type TFT 201 shown in Figure 15 (C). At this time, a drain line 35 of TFT 2402 for switching is connected electrically to a gate electrode 37 of TFT for controlling current with a wiring 36. Also, a wiring shown by 38 is a gate line which connects electrically gate electrodes 39a and 39b of TFT 2402 for switching.

[0149] At this time, it is very significant that TFT 2403 for controlling current has the structure of the present invention. TFT for controlling current is an element for controlling the quantity of current which flows in EL element, accordingly it has high dangerousness of deterioration by heat and hot carrier owing to a lot of current. Consequently, the deterioration of TFT can be prevented by providing an LDD region of which one portion is overlapped with a gate electrode in TFT for controlling current, and the stability of operation can be increased.

[0150] Besides, TFT 2403 for controlling current is shown by a single gate structure in the present embodiment, and a multi-gate structure that a plurality of TFTs are connected in series can be used. Furthermore, a structure can be used that a channel forming region is divided into plurality substantially by connecting a plurality of TFTs in juxtaposition so that radiation of heat is performed with high efficiency. Such structure is effective as measures of deterioration by heat.

[0151] Besides, as shown in Figure 28 (A), a wiring to be a gate electrode 37 of TFT 2403 for controlling current is overlapped with a drain line 40 of TFT 2403 for controlling current in the region shown by 2404 through an insulating film. At this time, a condenser is formed in the region shown by 2404. This condenser 2404 functions as a condenser for holding the voltage applied to the gate of TFT 2403 for controlling current. Besides, the drain line 40 is connected to a current supplying line (a power source line) 2501, to which the constant voltage is always applied.

[0152] A first passivation film 41 is provided on TFT 2402 for switching and TFT 2403 for controlling current, on which a planarizing film 42 made with a resin insulating film is formed. It

is very important that the step difference by TFT is planarized with the planarizing film 42. A self-emission layer formed subsequently is very thin, so that the inferiority of emission is sometimes caused by the step difference. Therefore, it is desirable that planarization is performed before forming a pixel electrode so as to form the self-emission layer on plane face as possible as it can.

[0153] Also, 43 is a pixel electrode (the cathode of EL element) made with a conductive film with high reflexibility, and is connected electrically to a drain of TFT 2403 for controlling current. It is preferable that a conductive film with low resistance such as an aluminum alloy film, a copper alloy film, a silver alloy film, etc., or a laminated film of those is used as the pixel electrode 43. Of course, the lamination structure with other conductive film can be used. Also, an light emission layer 44 is formed in a ditch (correspond to a pixel) formed by banks 44a and 44b made with an insulating film (preferably resin). Besides, only one pixel is shown in Figure, light emission layers corresponding to each color of R (red), G (green) and B (blue) can be formed separately. The π conjugate polymer series material is used as the organic EL material for the light emission layer. The typical polymer series materials are poly-para-phenylenevinylene (PPV) series, polyvinyl carbazole (PVK) series, poly fluorene series, etc. Also, there are various types as the PPV series organic EL materials, for example materials mentioned in "H. Shenk, H. Becker, O. Gelsen, E. Kluge, W. Kreuder, and H. Spreitzer, "Polymers for Light Emitting Diodes", Euro Display, Proceedings, 1999, p. 33-37" and Japanese Patent Application Laid-Open No. Heisei 10-92576 can be used.

[0154] As a concrete light emission layer, cyano phenylenevinylene can be used for a light emission layer of red emission, poly phenylenevinylene can be used for a light emission layer of green emission, and poly phenylenevinylene or poly alkylphenylene can be used for a light emission layer of blue emission. A film thickness can be 30 to 150 nm (preferably 40 to 100 nm). However, the above is an example of the organic EL material which can be used for the light emission layer, it is not necessary to be limited to them at all. The self-emission layer (a layer for light emitting and for making carrier move therefore) can be formed by combining freely a light emission layer, an electric charge transferring layer or an electric charge implanting layer. For example, an example of using a polymer series material as a light emission layer is shown in the present embodiment, and a monomer series organic EL material can be used. Also, an inorganic material such as silicon

carbide etc. can be used as the electric charge transferring layer and the electric charge implanting layer. The widely known materials can be used as these organic EL materials and the inorganic materials.

[0155] The self-emission layer having the lamination structure wherein a hole implanting layer 46 made with PEDOT (poly thiophene) or PAni (poly aniline) is provided on the light emission layer 45 is formed in the present embodiment. And then, the anode 47 made with a transparent conductive film is provided on the hole implanting layer 46. In case of the present embodiment, because the light produced by the light emission layer 45 is emitted toward the upper side (toward over TFT), the anode must be translucent. The compound of indium oxide and tin oxide and that of indium oxide and zinc oxide can be used for the transparent conductive film, however, it is formed after the light emission layer and the hole implanting layer with low heat-resistance are formed, accordingly it is preferable that it is formed at the temperature as low as possible.

[0156] As of forming the anode 47, a self-emission element 2405 is accomplished. Besides, the EL element 2405 indicates a condenser comprising the pixel electrode (the cathode) 43, the light emission layer 45, the hole implanting layer 46 and the anode 47. Because the pixel electrode 43 is almost equal to the area of pixel as shown in Figure 28 (A), the whole of pixel functions as the EL element. Therefore, the utilizing efficiency of light emission is very high so that the bright image displaying is possible.

[0157] By the way, in the present embodiment, a second passivation film 48 is provided further on the anode 47. A silicon nitride film or a silicon nitride oxide film is preferable for the second passivation film 48. This purpose is that the EL element is insulated with the outside, and has the both meanings of preventing deterioration by oxidation of the organic EL material, and of restraining gas from leaking out of the organic EL material. Accordingly, the reliability of the EL display device is improved.

[0158] As mentioned above, the EL display panel of the present invention has the pixel portion comprising pixels having the structure shown in Figure 28, TFT for switching of which OFF current value is low enough, and TFT for controlling current which is resistant to hot carrier implantation. Therefore, the EL display panel which has high reliability, and enables to display a fine image is obtained.

[0159] Figure 27 (B) shows an example that the structure of self-emission layer is reversed. TFT 2601 for controlling current is formed by using the p-channel type TFT 200 of Figure 15 (B). The manufacturing process can be referred to the embodiment 1. In the present embodiment, a transparent conductive film is used as a pixel electrode (the anode) 50. Concretely, a conductive film made with the compound of indium oxide and zinc oxide is used. Of course, the conductive film made with the compound of indium oxide and tin oxide can be also used.

[0160] And then, after banks 51a and 51b made with insulating films are formed, a light emission layer 52 made from polyvinyl carbazole is formed by applying solution. An electron implanting layer 53 made from potassium acetyl acetonate (referred to as acacK), and the cathode 54 made of aluminum alloy are formed thereon. In this case, the cathode 54 functions as a passivation film. In this way, the EL element 2602 is formed. In the present embodiment, the light produced by the light emission layer 53 is emitted toward the substrate on which TFT is formed as shown by an arrow. When the structure such as the present embodiment is used, it is preferable that TFT 2601 for controlling current is formed with a p-channel type TFT.

[0161] Besides, the constitution of the present embodiment can be performed by combining freely the constitutions of TFT of the embodiments 1 to 2. Also, it is effective that the EL display panel of the present embodiment is used as the displaying portion of the electron apparatus of the embodiment 8.

[0162] [Embodiment 7] In the present embodiment, Figure 29 shows an example in case of a pixel having different structure from the circuit diagram shown in Figure 28 (B). Besides, in the present embodiment, 2701 is a source wiring of TFT 2702 for switching, 2703 is a gate wiring of TFT 2702 for switching, 2704 is TFT for controlling current, 2705 is a condenser, 2706 and 2708 are current supplying lines, and 2707 is an EL element.

[0163] Figure 29 (A) is an example when the current supplying line 2706 is in common with two pixels. That is to say, it is characterized by forming two pixels so as to be line symmetry by making the current supplying line 2706 the center line. In this case, because the number of the power source supplying lines can be reduced, the pixel portion can be high definition further.

[0164] Besides, Figure 29 (B) is an example of providing the current supplying line 2708 in parallel with the gate wiring 2703. Also, the structure that the current supplying line 2708 is not

overlapped with the gate wiring 2703 is shown in Figure 29 (B). If both are formed in different layers, they can be provided so as to be overlapped through an insulating film. In this case, the current supplying line 2708 and the gate wiring 2703 can hold a monopolizing area in common, so that the pixel portion can be high definition further.

[0165] Also, Figure 29 (C) is characterized by providing the current supplying line 2708 in parallel with the gate wiring 2703 in the same way as the structure of Figure 29 (B), furthermore by forming two pixels so as to be line symmetry by making the current supplying line 2708 the center line. Besides, it is effective that the current supplying line 2708 is provided so as to be overlapped with any one of the gate wirings 2703. In this case, because the number of the power source supplying lines can be reduced, the pixel portion can be high definition further. In Figure 29 (A) and Figure 29 (B), though the structure that a condenser 2404 is provided in order to hold the voltage applied to the gate of TFT 2403 for controlling current is shown, the condenser 2404 can be omitted.

[0166] Because the n-channel type TFT of the present invention as shown in Figure 27 (A) is used as TFT 2403 for controlling current, the LDD region is provided so as to overlap with the gate electrode through the gate insulating film. A parasitic capacity which is referred to as a gate capacity generally is formed in this overlapped region, and it is characterized by using this parasitic capacity positively instead of the condenser 2404 in the present embodiment. The capacitance of this parasitic capacity is changed by the area where the gate electrode mentioned above and the LDD region are overlapped each other so that it is decided by the length of the LDD region which is included in the overlapped region. Besides, the condenser 2705 can be omitted in the structures of Figure 29 (A), (B) and (C) in the same way.

[0167] Besides, the constitution of the present invention can be performed by combining freely the constitutions of TFT of the embodiments 1 to 2. Also, it is effective that the EL display panel of the present embodiment is used as a displaying portion of an electronic apparatus of the embodiment 8.

[0168] [Embodiment 8] In the present embodiment, a semiconductor device wherein an active matrix type liquid crystal display device by TFT circuit of the present invention is inserted is explained in Figures 30, 31 and 32.

[0169] Such semiconductor device is used in portable information terminals (electronic pocketbook,

mobile computer, portable telephone, etc.), video camera, still camera, personal computer, television set, etc. One example of them is shown in Figures 30 and 31.

[0170] Figure 30 (A) is a portable telephone comprising a body 9001, a voice output portion 9002, a voice input portion 9003, a display device 9004, an operation switch 9005, and an antenna 9006. The present invention can be applied to the voice output portion 9002, the voice input portion 9003, and the display device 9004 with an active matrix substrate.

[0171] Figure 30 (B) is a video camera comprising a body 9101, a display device 9102, a voice input portion 9103, an operation switch 9104, a battery 9105, and a television portion 9106. The present invention can be applied to the voice input portion 9103, the display device 9102 with an active matrix substrate, and the television portion 9106.

[0172] Figure 30 (C) is a mobile computer or a portable type information terminal comprising by a body 9201, a camera portion 9202, a television portion 9203, an operation switch 9204, and a display device 9205. The present invention can be applied to the television portion 9203 and the display device 9205 with an active matrix substrate.

[0173] Figure 30 (D) is a head mount display comprising a body 9301, a display device 9302 and an arm portion 9303. The present invention can be applied to the display device 9302. Also, it can be used in other signal controlling circuit, which is not shown in Figure.

[0174] Figure 30 (E) is a television set comprising a body 9401, a speaker 9402, a display device 9403, a receiving device 9404, an amplifier 9405, etc. The liquid crystal display device shown in the embodiment 5 and the EL display device shown in the embodiment 6 or 7 can be applied to the display device 9403.

[0175] Figure 30 (F) is a portable book comprising a body 9501, display devices 9502 and 9503, a memory medium 9504, an operation switch 9505 and an antenna 9506, and it displays data which are memorized in mini disc (MD) and DVD, and data which is received by antenna. The display devices 9502 and 9503 are direct view display devices, to which the present invention can be applied.

[0176] Figure 31 (A) is a personal computer comprising a body 9601, an image input portion 9602, a display device 9603 and a keyboard 9604.

[0177] Figure 31 (B) is a player using a recording medium wherein a program is recorded

(hereinafter referred to as recording medium), comprising a body 9701, a display device 9702, a speaker portion 9703, a recording medium 9704 and an operation switch 9705. Besides, music appreciation, movie appreciation, game and internet can be performed by using DVD (Digital Versatile Disc), CD, etc. as a recording medium in this apparatus.

[0178] Figure 31 (C) is a digital camera comprising a body 9801, a display device 9802, an eyepiece portion 9803, an operation switch 9804 and a television portion (not shown in Figure).

[0179] Figure 32 (A) is a front type projector comprising a display device 3601 and a screen 3602. The present invention can be applied to the display device and other signal controlling circuit.

[0180] Figure 32 (B) is a rear type projector comprising a body 3701, a projecting device 3702, a mirror 3703 and a screen 3704. The present invention can be applied to the display device and other signal controlling circuit.

[0181] Besides, Figure 32 (C) shows one example of the structure of projecting devices 3601 and 3702 in Figure 32 (A) and Figure 32 (B). The projecting devices 3601 and 3702 are constituted by a light source optical system 3801, mirrors 3802, 3804 to 3806, a dichroic mirror 3803, a prism 3807, a liquid crystal display device 3808, a phase difference plate 3809 and a projecting optical system 3810. The projecting optical system 3810 is constituted by the optical system including a projection lens. An example of three plates system is shown in the present embodiment, however it is not limited especially, for example single plate system can be used. Also, an optical system such as an optical lens, a film having polarizing function, a film for regulating the phase difference, an IR film, etc. can be provided in an optical path shown by an arrow in Figure 32 (C) suitably by performers.

[0182] Besides, Figure 32 (D) is a view showing one example of a structure of a light source optical system 3801 in Figure 32 (C). In the present embodiment, the light source optical system 3801 comprises a reflector 3811, a light source 3812, a lens arrays 3813 and 3814, a polarizing conversion element 3815 and a condensing lens 3816. Besides, the light source optical system shown in Figure 32 (D) is one example, accordingly it is not limited especially. For example, an optical system such as an optical lens, a film having polarizing function, a film for regulating the phase difference, an IR film, etc. can be provided in a light source optical system suitably by performers.

[0183] Besides, the present invention can be also applied to an image sensor and an EL type display element. In this way, an application range of the present invention is very wide, so that it can be applied to electronic apparatus in every field.

[0184]

[Effect of the present invention] According to the present invention, it is possible to perform a heat treating by using a laser beam on the specified region of a substrate of which one side is longer than the length in the longitudinal direction of the laser beam, by providing a slit for regulating the length in the longitudinal direction of a linear laser beam formed by an optical system. The heat treating by using a laser beam of the present invention can be applied to a laser crystallization method and a heat treating for activating one-conductive type impurity element. When such heat treating method by using a laser beam and a laser apparatus of the present invention, TFT having fine characteristics can be manufactured, and also the productivity can be improved. A liquid crystal display device and an EL display device can be manufactured by using such active matrix substrate.

[0185] Besides, a laser apparatus is constituted by the present invention, so that a heat treating by using laser beam can be performed to a large-sized substrate without making the apparatus large-scaled.

[A brief explanation of Figures]

[Figure 1] An explanatory view of a heat treating method to a semiconductor film by using a laser beam of the present invention.

[Figure 2] An explanatory view of a constitution of a laser apparatus of the present invention.

[Figure 3] An explanatory view of a constitution of a laser apparatus of the present invention.

[Figure 4] An explanatory view of a constitution of an optical system of a laser apparatus of the present invention.

[Figure 5] An explanatory view of a constitution of an optical system of a laser apparatus of the present invention.

[Figure 6] An explanatory view of a constitution of an optical system of a laser apparatus of the present invention.

[Figure 7] An explanatory view of a constitution of a light transmission medium.

[Figure 8] An explanatory view of a constitution of an optical system of a laser apparatus of the

present invention.

[Figure 9] An explanatory view of a method for forming a crystalline semiconductor film by a heat treating method to a semiconductor film by using a laser beam of the present invention.

[Figure 10] An explanatory view of a method for forming a crystalline semiconductor film by a heat treating method to a semiconductor film by using a laser beam of the present invention.

[Figure 11] An explanatory view of a method for forming a crystalline semiconductor film by a heat treating method to a semiconductor film by using a laser beam of the present invention.

[Figure 12] An explanatory view of a heat treating method to a semiconductor film by using a laser beam of the present invention.

[Figure 13] A cross sectional view showing a manufacturing process of a pixel TFT and a TFT of driving circuit.

[Figure 14] A cross sectional view showing a manufacturing process of a pixel TFT and a TFT of driving circuit.

[Figure 15] A cross sectional view showing a manufacturing process of a pixel TFT and a TFT of driving circuit.

[Figure 16] A cross sectional view showing a manufacturing process of a pixel TFT and a TFT of driving circuit.

[Figure 17] An upper side view showing a structure of a TFT of driving circuit and a pixel TFT.

[Figure 18] A cross sectional view showing a structure of a TFT of driving circuit and a pixel TFT.

[Figure 19] A cross sectional view showing a manufacturing process of a pixel TFT and a TFT of driving circuit.

[Figure 20] A cross sectional view showing a manufacturing process of a pixel TFT and a TFT of driving circuit.

[Figure 21] A cross sectional view showing a manufacturing process of an active matrix type liquid crystal display device.

[Figure 22] A cross sectional view showing a constitution of an active matrix type liquid crystal display device.

[Figure 23] An upper side view explaining an input terminal, a wiring, and a circuit arrangement and an arrangement of a spacer and a sealing agent of liquid crystal display device.

[Figure 24] An oblique view explaining a constitution of a liquid crystal display device

[Figure 25] An upper side view of a pixel of a pixel portion.

[Figure 26] An upper side view and a cross sectional view showing a structure of an EL display device.

[Figure 27] A cross sectional view of a pixel portion of an EL display device.

[Figure 28] An upper side view and a circuit diagram of a pixel portion of an EL display device.

[Figure 29] An example of a circuit diagram of a pixel portion of an EL display device.

[Figure 30] A view of an example of a semiconductor device.

[Figure 31] A view of an example of a semiconductor device.

[Figure 32] A view showing a constitution of a projecting type liquid crystal display device.